ENVIRONMENTAL QUARTERLY

Science

April • 1961

The Pioneer Space Age Publication of Environmental Simulation, Testing, Engineering and Equipment Manufacturing

INDEPENDENTLY PUBLISHED

Volume 7 • Number 2

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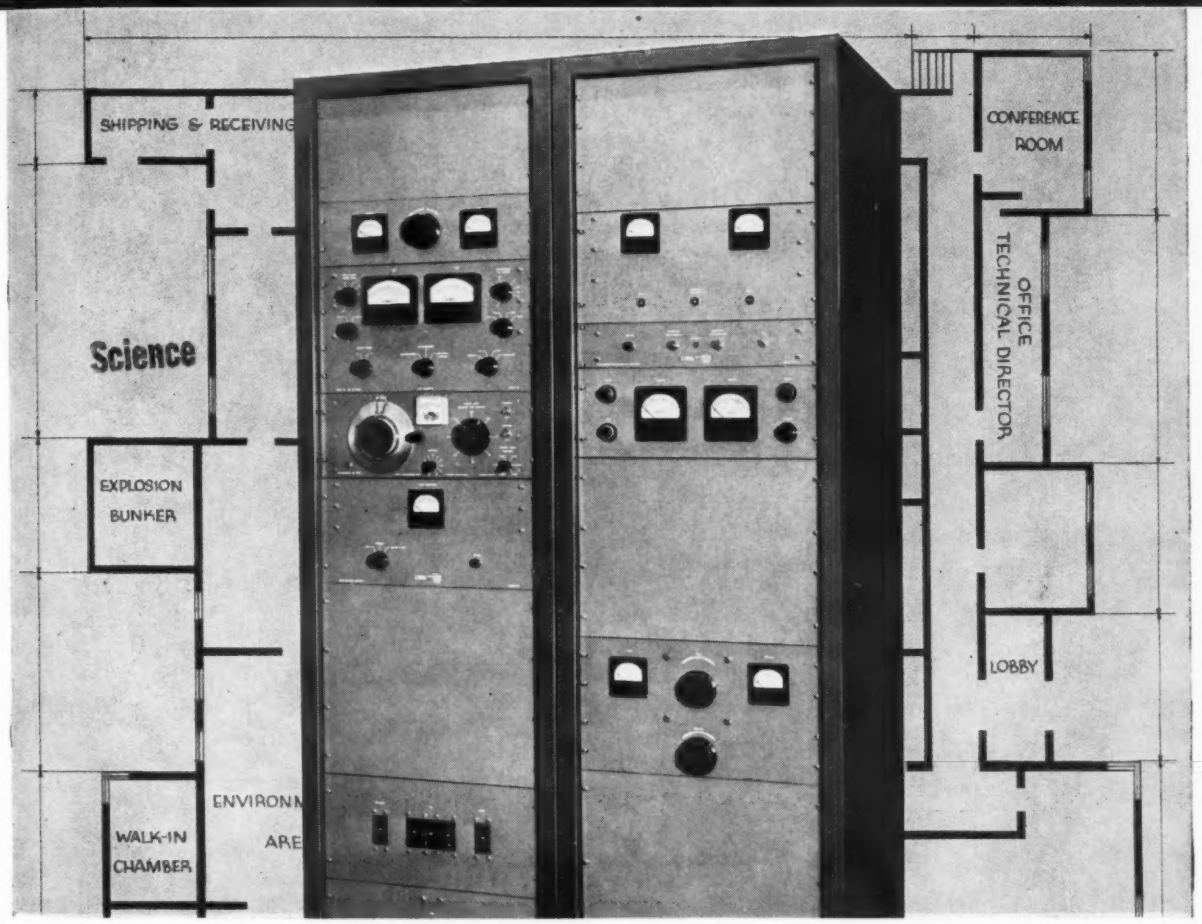

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Now Ling brings you Sine-O-Matic amplifiers requiring little more space than two standard file cabinets. These amplifiers incorporate Ling's standard high efficiency designs, low maintenance requirements, and personnel and equipment safety features. The compact Sine-O-Matic is completely packaged to provide a fully automatic cycling, sine wave vibration testing system with ratings from 500 to 1750 pounds force. All necessary components are housed in an area that requires only 8.2 square feet of floor space. This includes the 5000 VA amplifiers Model RP 5/6 for driving electrodynamic shakers, field and degaussing supply, cycling oscillator, servo system, metering and controls. The only other component necessary is the shaker itself. Capabilities of crowded production areas or testing laboratories now can readily be augmented by use of Ling's space saving Sine-O-Matic Systems. Ling's Sine-O-Matic amplifier is available in 3000 VA or 5000 VA ratings in both sit-down desk-type consoles, or in the new upright console featured above, mating with shakers to provide systems with 500 to 1750 pounds force output. For details of Ling's Sine-O-Matic Systems, write to Department EQ-461 at the address below.

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LING ELECTRONICS DIVISION

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- Are its specifications proven by accurate testing and calibration?
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- Are they produced by a reputable manufacturer with sufficient experience in the production of piezoelectric accelerometers to insure maximum design reliability and application know-how?
- Does the manufacturer provide repair service for the lifetime of the product?

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For complete technical details about Endevco instrumentation write to:

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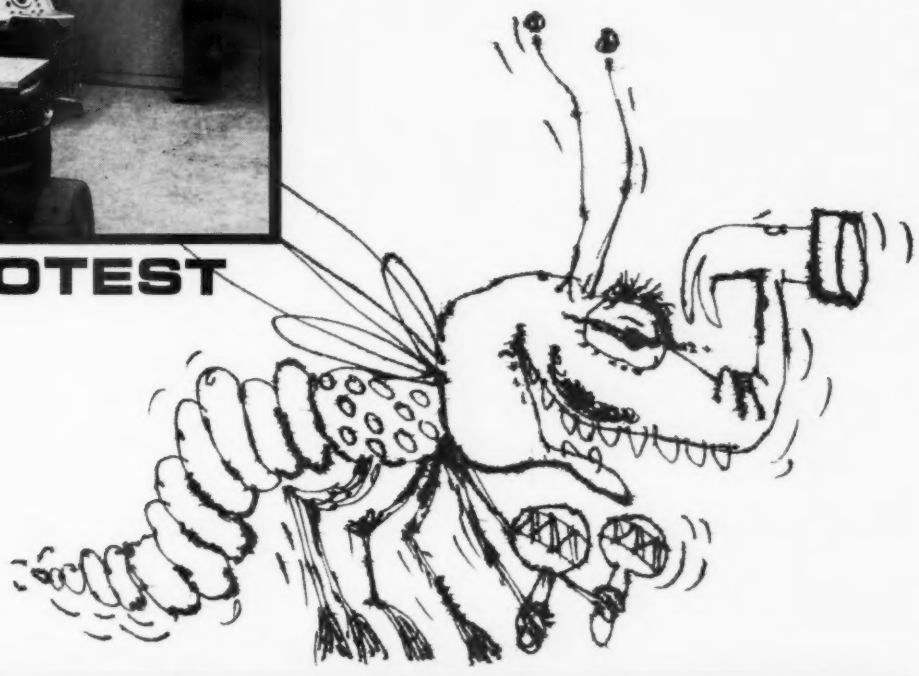

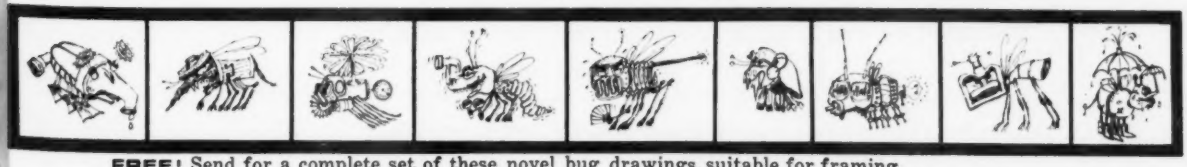

FREE! Send for a complete set of these novel bug drawings, suitable for framing.

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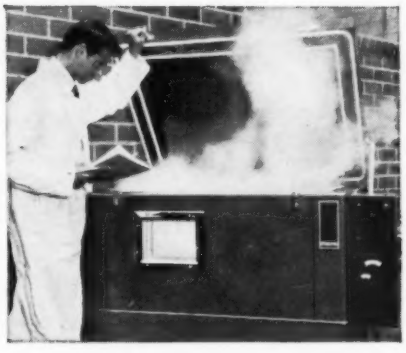
...WITH PURECO CO_2 "BLAST COLD"



Quick test chamber temperature pull-down. (Direct cooling)

The Pureco CO_2 *Blast Cold* process provides an extremely high rate of temperature pull-down. Temperatures can be reduced from as much as 2000°F to —100°F in minutes. Fluctuation of temperatures caused by "over-ride" are eliminated ... tolerances of ± ½° are easily achieved. The possibility of refrigeration failure is eliminated. The Blast Cold process is completely reliable.

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The equipment necessary for the Pureco CO_2 *Blast Cold* process is extremely simple. CO_2 receivers are normally supplied and maintained by Pure Carbonic on the customer's premises. Since many environmental testing jobs are scattered around in plants, Pureco now supplies portable CO_2 receiver units of 1000 lb. capacity in addition to fixed units up to 60 tons or more capacity.

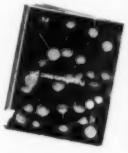
CO_2 liquid for indirect cooling.

Pureco CO_2 liquid is discharged directly into a circulating refrigeration solution when it is necessary to keep the test chamber free of CO_2 atmosphere.

Pureco "DRY-ICE" a quick, low-cost refrigerant for direct or indirect cooling.

Pureco "DRY-ICE" provides a simple, inexpensive method of reducing test chamber temperatures down to —109°F.

New Pureco booklet "How Carbon Dioxide Serves You". Write for free copy.



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Nation-Wide Pureco CO_2 Service-Distributing Stations in Principal Cities
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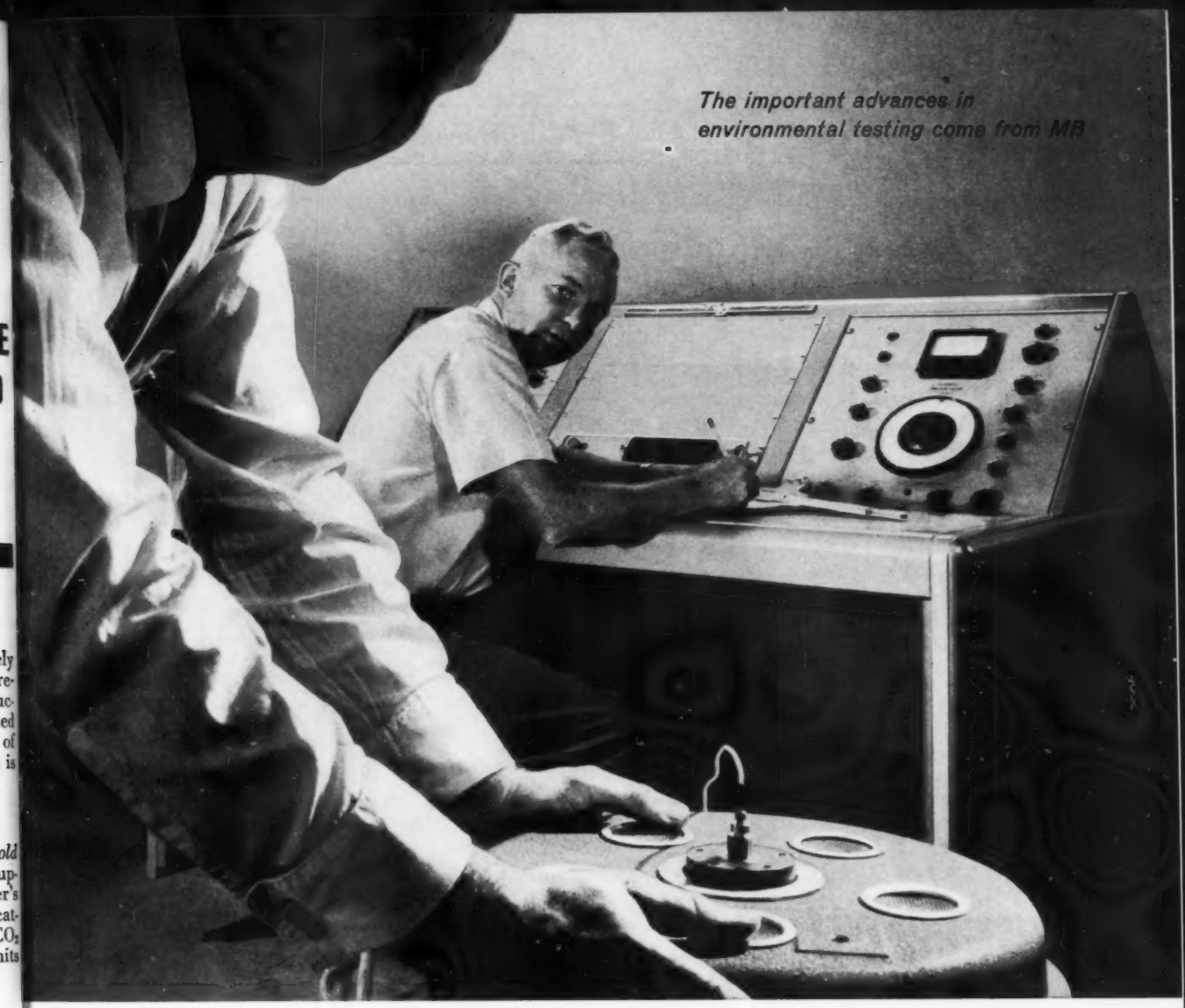
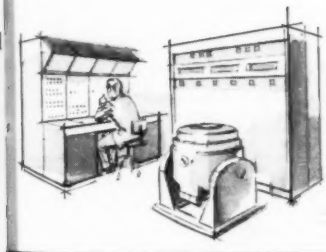
AT THE FRONTIERS OF PROGRESS YOU'LL FIND AN AIR REDUCTION PRODUCT



New MB vibration unit extends range, accuracy and efficiency of accelerometer calibration



The C12 moving element is a solid magnesium casting. This design guarantees pure linear motion, an absolute requirement for accurate calibration. Amplifier and controls are enclosed in desk type console with ample panel space for accessories making up complete calibration system.

Now, for the first time, a single system enables you to accurately calibrate vibration transducers at any frequency from 5 to 10,000 cps with accelerations up to 100 g.

Complete and self-contained, the MB calibration system saves you space, time and money. This entirely new system incorporates all the necessary instrumentation required for fast, accurate calibration. Newly designed circuits simplify calibration procedure and eliminate special techniques.

Powered by an extremely low distortion amplifier, the MB Model C12 calibrator produces 150 pounds of high-fidelity linear force.

The new exciter-calibrator pictured above is another example of MB's continuing efforts to anticipate the needs of the environmental test engineer. It is another reason why engineers everywhere recognize that *the important advances in environmental testing come from MB.*

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC., 1057 State Street, New Haven 11, Conn.

You will hear about PreKorder at the IES meeting. See it in Booths 37 & 38

Both a

PROGRAMMER

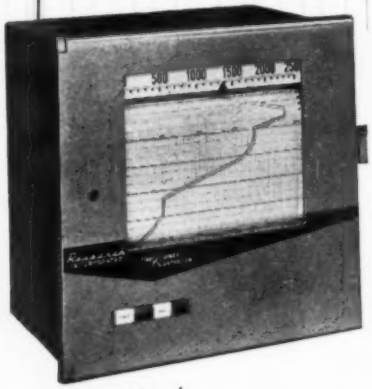
guided by a pencil-drawn curve

NO CAMS

and a

RECORDING CONTROLLER

which superimposes a record of actual process performance and applies corrective control when performance deviates from the plotted program



PREKORDER
TRADE-MARK

brings new flexibility to the automation of industrial process with closed-loop control.

1. **Pencil Programming** — No cams to cut.
2. **Superimposed Recording** — PreKorder's permanent record of process performance on a program chart overlay permits continuous visual comparison of record and chart.
3. **Programmed Limits** — To trigger alarm or shut-down circuits in case of process malfunction, just pencil allowable operating limits on the recording chart.
4. **Programmed Gain** — Varying the space between pencilled program lines varies the proportional control band or system gain.

Typical PreKorder applications are in programming temperature, pressure, power, load, flow, position, and other process variables. Both round and strip-chart models are available.

R I RESEARCH INCORPORATED

Write Dept. FT, Box 6164, Minneapolis 24, Minn.

ENVIRONMENTAL QUARTERLY

The Pioneer Space Age Publication of Environmental Simulation, Testing, Engineering and Equipment Manufacturing

April • 1961 Volume 7 • Number 2

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Quarterly welcomes competent expressions of opinion, but statements in its pages do not necessarily reflect its views. Right is reserved to extract portions of letters and other material submitted for publication. Correspondents must be fully identified, but names will not be published if such a request is made.

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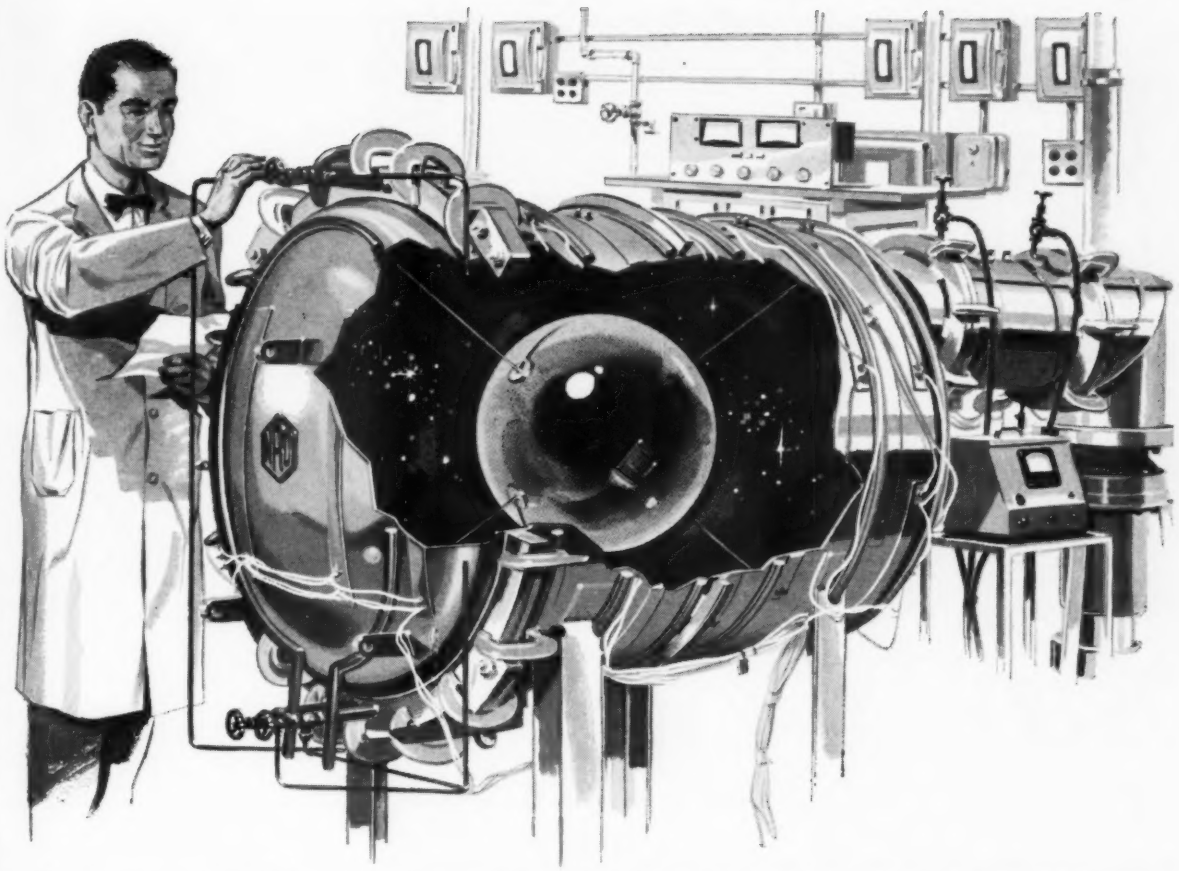


at your service.....**THE MOST PRACTICAL SIMULATION OF SPACE VACUUM ON EARTH!**

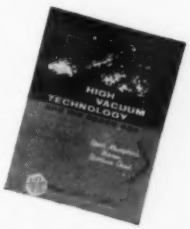
Only NRC tests large and small components for reliability down to the 10^{-10} mm Hg range!

Your space-bound materials or components will never reach their goal if they can't survive the first test of space simulation—ultrahigh vacuum. NRC creates these conditions in its laboratory—pressures in the 10^{-10} mm Hg range—equivalent to orbiting altitudes above 500 miles.

The step to 10^{-10} mm Hg may be critical. Important changes may occur in materials exposed to such vacuum. Metals stripped of their oxide coatings and materials sapped of their volatile constituents can pose new problems in friction, lubrication, heat transfer, tensile strength, emissivity, electrical conductivity and other vital properties. You must know what changes occur and how they affect performance.

NRC's Space Vacuum Laboratory is unique. Our chambers up to 50 cubic feet are handling spacecraft components now. We're testing cable materials for a communications satellite, cycling temperatures and loads on electronic parts and operating space vehicle antenna drive mechanisms. We're learning about space lubricants, bearing behavior and surface properties of materials. We're improving capsule seals. We can keep a clean, reliable ultrahigh vacuum.

How can we help you? Write today for *SVL Data* . . . including upper atmosphere vacuum spectrum chart and daily rate schedules. The address: Contracts Manager, NRC Research Division, 70 Memorial Drive, Cambridge 42, Mass.



For personal discussion during I. E. S. Exhibit, April 5-7, in Washington, D. C., visit NRC Booth 99.

RESEARCH DIVISION
National Research Corporation

CompuDyne's DYNATEST* machine loads 50,000 pounds at 20 cps and can follow a programmed heating rate of 200°F/sec. to 3000°F simultaneously

Now you can get dynamic response characteristics well beyond the capabilities of conventional test machines by using DYNATEST Model DTM-3. The new machine meets demands created by rapid technological developments in nuclear, aeronautical, space vehicle and propulsion fields.

The Dynatest machine features a high-speed DYNAJACK* electrohydraulic ram arranged to program force and strain applied to the specimen. Continuous cyclical force or strain versus time may be employed with manual or full automatic programming. Temperature programming is accomplished by close coupled resistance heating or combinations of resistive inductive or radiant heating. Temperature is detected with a low mass thermocouple welded to the specimen.

Special environmental testing is greatly simplified because the Dynajack hydraulic load cylinder, load cell, and extensometer are easy to remove and can be placed in special jigs if necessary.

Complete specifications and details are in Data Sheet S-101. Write for your copy today.

**Tradename*

CompuDyne Corporation

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Post Scripts

Sharing Experience . . .

Behind Bill Tonkowich's article, "Designing for Qualification," in the last issue of *Environmental Quarterly* (Vol. 7, No. 1, Pg. 17), was an effort to help others benefit from the diversified experiences of a busy test lab. The same thought is expressed by S. P. Sanders, whose article, "Environmental Imagineering," appears to this issue.

In offering for publication an account of problems met and solved by Bendix' environmental lab in Mishawaka, Ind., he wrote:

"I believe firmly that the working engineer would benefit tremendously if more people would document the relatively simple problems and solutions they encounter in their work. I also believe the failures should be reported to save the time that might be wasted by someone else who is using the same approach."

. . . and Presenting Ideas

Wishing, if we may disagree with the old ballad, does not always make it so. And as many engineers will testify, wanting to communicate is not quite the same as getting ideas across.

Dr. Max A. Pape and Mrs. Pape, known professionally as Nikki Kaye, psychologist and advertising consultant, have put down on paper some thoughts on "The Presentation of Ideas." Readers of *Environmental Quarterly* will remember Dr. Pape as the author of "Task Equipment Analysis and Environmental Testing" in the July, 1959 issue (Vol. 5, No. 3, Pg. 16). Then at Stanford Research Institute, Dr. Pape is now director of publications of Northrop Corporation.

Listen to Dr. Pape and his wife:

"Worse than None at All"

At every career level, engineers are called on to present ideas in concrete, written form. A poorly presented idea is worse than none at all.

Engineers are in the business of advertising and selling. Every time an engineer explains an idea he is "selling," and every time he "sells" he is advertising himself, his way of doing things and his knowledge.

Engineers sell far more than ideas. They sell subordinates on doing a job well; they sell supervisors and management on their way of doing things; they sell suppliers on delivery schedules; they sell other persons and other departments on cooperation and on budgetary matters. This selling is business. It is necessary in order to do a job efficiently.

Of all the callings, advertising is probably the most knowledgeable about presenting ideas. Let us borrow a leaf.

A thorough survey and an educated guess, Dr. and Mrs. Pape continue, may lead an ad agency to recommend that a client use a different approach and different media to increase sales. Each department in the agency will contribute to the recommendation, the information being filtered back to the individual finally responsible for preparing the presentation.

In the engineer's language, this process translates to: Inputs from various departments and various functions are filtered to a certain place or person, where they are collated, categorized and analyzed.

Advertising knows something that engineers are just beginning to discover. It is called selectivity, which advertising's own experts agree is the one word that best describes the greatest principle in the art of advertising and selling. Advertisers know they cannot sell all of the people all of the time; they know they cannot boast of all the virtues of a product in every ad, so they *select*. First, they select the audience an ad will reach, and then they select the theme an ad will carry.

One Theme Only

What is true of an ad is true of an advertising presentation. No matter how complex the subject, one theme and only one is stressed. The most complex situation is reduced to a simple, basic idea. Advertising agencies, skilled in selling ideas to management, know from experience that only one idea can be established, clarified and analyzed at a time.

Detailed figures, statistics, graphs and charts are translated into the same simple, basic thought pattern, but they are not crowded into the presentation itself. Every statement is substantiated, but usually for quick reference, in an indexed, looseleaf binder with subjects under easily identifiable headings.

This is the framework of a presentation—any presentation, written or spoken, or both.

How the engineer gathers his material for it, how he plans it and how he

Words Without Music

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IF YOU'RE READING THIS ISSUE...
THERE'S AN ASSOCIATED TESTING LAB NEAR YOU!

With the opening of our newest testing laboratory in Burlington, Massachusetts on March 15th, Associated's quality environmental testing facilities are in range to serve the entire eastern area, from New England to the South. Associated Testing Laboratories, Inc. now has laboratories in Burlington, Massachusetts, Wayne, New Jersey, and Winter Park, Florida.

At each of the Associated divisions you will find the most extensive lines of environmental testing equipment ever seen. A good part of this varied equipment has been designed and produced in our manufacturing division to meet our own rigid standards. Each testing division also boasts complete recording and indicating instrumentation for all the electronic, electrical, pneumatic and hydraulic measurements basic to environmental tests.

Included among Associated's comprehensive testing facilities are Sinusoidal and Random Vibration, Variable Pulse Shock, Temperature, Altitude, Humidity, Explosion, Sand and Dust, Acoustic Noise, Temperature-Altitude, Salt Spray and Radial Acceleration testing. Other equipment includes hydraulic and pneumatic test stands.

Visit us at the IES Show—Booths 47-48 • Write for our 1961 Facilities Brochure

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TESTING DIVISIONS

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WAYNE, NEW JERSEY
Telephone: CLifford 6-2800
TWX: LT FS NJ 943

1112 SOLANA AVENUE
WINTER PARK, FLORIDA
Telephone: MIdway 4-1800
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The CVC-built HIVOS (High Vacuum Orbital Simulator) will test the Lockheed Agena—can be expanded to accommodate advanced versions of Agenas.

A little bit of heaven here on earth! That's what Consolidated Vacuum is building for LOCKHEED'S MISSILES AND SPACE DIVISION, to put the Agena ... Lockheed's vehicle for the Air Force Discoverer, Midas and other advanced satellite systems ... through all the punishment of actual orbit: blistering solar radiation ... the near-absolute-zero cold of the earth's shadow ... the incomprehensibly low pressure of one/one-hundred-billionth of sea-level atmosphere.

The same CVC capabilities are ready to provide complete turn-key facilities for *your* reliability testing program. Just check with your nearest CVC Sales Office, or the Custom Products Division, CVC, 1775 Mt. Read Blvd., Rochester 3, N. Y.

CVC *Consolidated Vacuum Corporation*

ROCHESTER 3, NEW YORK

A SUBSIDIARY OF CONSOLIDATED ELECTRODYNAMICS/BELL & HOWELL

dresses it up for the eye is a test of his imagination.

The Promise of the Premise

To return to the advertising agency approach, first there is the basic premise that sales can be increased with a change in sales approach. Graphs and charts show present and potential markets. Next, to answer the question of how sales can be increased, the agency uses inputs from marketing, research, media and plans. For a few sample ads using the new approach, the agency uses inputs from its art and copy departments.

Every facet of the proposed new campaign is *not* covered . . . that would clutter the presentation and overwhelm the audience. The spotlight shines on only the high points, clarifying the verbal treatment.

The idea itself is presented simply, clearly, without unnecessary clutter; without unnecessary detail. Visual material is the icing on the cake of the verbal presentation.

Prepare, Select, Prepare

Granting that this is an over-simplification, nevertheless notice certain points. It takes longer to write about preparing the presentation than to make the presentation itself. So it is in reality: Preparation should be two-thirds to three-quarters of the work. Engineers have a great deal of material from which to select. The impulse to tell everything and to overwhelm the audience with a wealth of detail must be controlled. Remember selectivity. Select carefully without losing sight of the basic idea.

Most companies have a set format to be followed but this merely refers to size of paper, use of color, size of charts and so forth. Within the format, a presentation should follow the following steps along a sure road to success:

1. Reduce an idea to its simplest fundamentals. (You yourself must have a clear concept of what you expect to accomplish.)

2. If a change in approach is being suggested, compare the new idea (yours) with the old. Compare simply, graphically.

3. Show where the new is better than the old—more effective, money-saving, time-saving, or whatever point you are making.

4. Substantiate, but not as part of the presentation itself. Documentation is indexed reference material. Keep it that way.

5. And remember the one big word in advertising and selling: selectivity. Select your method of presentation, and select your material.

Husbanding Resources

How to obtain the assurance of a comprehensive environmental testing program while holding the indicated prodigious expenditure of time and money to reasonable levels is no mean problem for the managers of the space program.

A convincing answer comes from three seasoned statisticians, Norman R. Garner,

D. E. Hartvigsen and S. Roy Wood, all of Aerojet-General Corporation Their "Minimization of Test Programs" elsewhere in this issue is recommended reading.

Acoustical Frontiersmen

Minimized or not, test results can be only as good as the available simulation equipment and the ingenuity with which it is used. More on the latter shortly. For the nonce, the spotlight is on equipment.

Recognizing the urgent need for thorough-going presentation of equipment capabilities and potentials, *Environmental Quarterly* last issue introduced a new feature dubbed "New Product Spotlight." This material is prepared by the manufacturer but, granted his partiality to his handiwork, is as technically sound as possible. The author of the current "Spotlight" is Tenney Engineering, Inc.'s acoustics expert, Bill Dunn. Hear his comment:

State of the Art

"The state of the acoustical art in aeronautical and missile engineering advances with each passing day. New and more theoretical approaches are being devised, and the art is trying to become a science. In the process, flight vehicle managers are becoming more amenable to accepting predicted data as fairly well representing the actual environment.

"The rapid strides now make it possible to foresee many acoustic problems prior to flight test time. Planning of expenditures, personnel, time, and equipment can be made with a higher degree of accuracy than ever.

"Hand in hand with predicting is the need for accurate measuring and testing devices. Equipment must be variable to the extent of providing valid and repeatable data over large frequency, peak to rms and pressure ranges.

Noise Simulation Problems

"The acoustical engineer concerned with laboratory simulation of flight vehicle noise is faced with a number of perplexing problems:

¶"Is sinusodial or random noise excitation most suitable for his purpose?

¶"Can a high-intensity noise be generated satisfactorily in the laboratory?

¶"Can a large-volume test chamber sustain high intensity noise?

¶"Is the desired frequency range attainable?

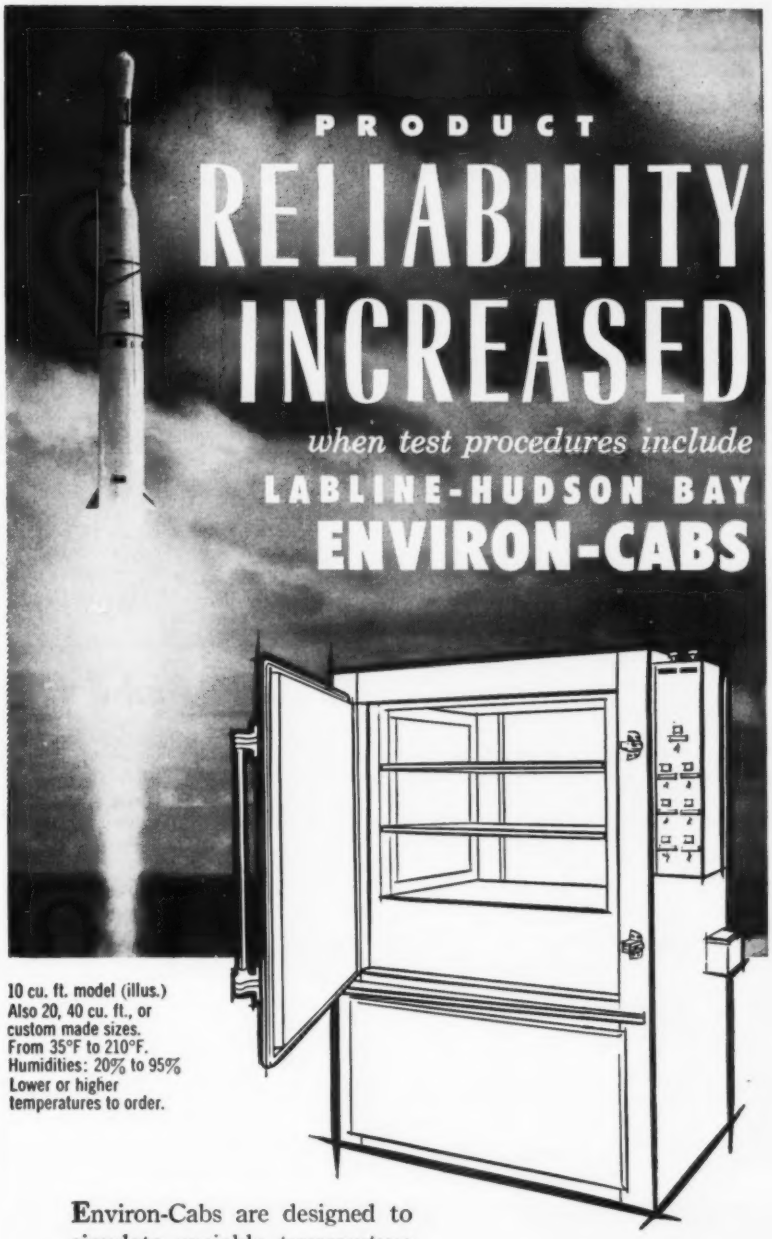
¶"How accurate a peak to rms ratio can be reproduced?

¶"How long can this environment be maintained?

¶"Is the test reproducible?

¶"What will it cost?"

Acoustical test equipment, to date, has not been able to supply the answers, Mr. Dunn adds, but development work by Tenney Engineering has resulted in a series of high-intensity wide-band noise generators and test chambers that have such capability. For a description of the generators, turn to "New Product Spotlight."



10 cu. ft. model (illus.)
Also 20, 40 cu. ft., or custom made sizes.
From 35°F to 210°F.
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AROUND THE ENVIRONS...

Washington to Be Nation's Environmental Capital April 5-7

More than 1,000 Visitors Expected at IES Meeting

More than 1,000 convention-goers from all parts of the country are expected to attend the annual meeting of the Institute of Environmental Sciences April 5-7 at the Sheraton-Park Hotel, Washington D.C.

A wide-ranging technical program awaits them in three parallel morning and afternoon sessions during the three-day conference. Some 70 papers are on tap, representing contributions by all major weapons system contractors, research institutes and government test agencies. The full program was published in the January, 1961, issue of Environmental Quarterly.

The theme of the 1961 IES meeting, "Global and Space Environments as a Challenge to Industry," will also be carried out in extensive exhibits by major environmental equipment and instrumentation manufacturers. *(A list of exhibitors appears elsewhere in this issue.)*

A highlight of the three-day meeting will be the Thursday, April 6, luncheon, at which Kurt Stehling, of NASA, will speak on "The Challenge of Space." He last appeared before the IES at the 1958 meeting in New York.

Results of the IES national election will be announced at lunch on opening day, Wednesday, April 5.

A pre-meeting feature for those who arrive in Washington on Tuesday will be a tour of the David Taylor Model Basin in the afternoon. There will be a full program for wives, starting with a tea at 4 p.m. Tuesday and including a tour of the White House.

Even as this year's meeting date approached, the IES was making plans for its 1962 convention. Henry F. Sander,

(Continued on Page 13)

Arthur Billet is Unopposed for Presidency, But Contests Develop for Other IES Posts

Arthur B. Billet, executive vice president of the Institute of Environmental Sciences, was virtually assured of election as president in balloting going on in advance of the society's annual meeting, but an unusual number of contests developed for all other offices.

The election was being conducted by mail, with ballots due at the society's national office before April 1. Results were expected to be announced at the annual meeting.

Three-way races were in progress for the fiscal vice presidency and vice president-membership. The former pitted Jerome Bakalish, of Colorado, against Mark Christensen, of California, and Richard Hahn, of New Jersey. Opponents in the latter contest were Joseph Gaudet, New Hampshire, Daniel Grady, Pennsylvania and Herbert Saunders, Illinois.

For the office of executive vice president, traditional stepping-stone to the presidency, the candidates were Donald Fox, of Illinois, and Martin Schletter, of New Jersey. John Campbell, of California, and Norman Ponge, New York, were running for the job of vice president-publications, and Gerhard Doering, of Pennsylvania, and William Falkner, Washington State, both sought the local chapters vice presidency.

Latest Equipment, Techniques on View

Some 45 manufacturers and environmental servicing organizations will place their latest innovations on view at the equipment exposition being held concurrently in the Sheraton-Park Hotel with the IES meeting. With "live" models where feasible, and photos, mockups and scale models where not, the displays will cover a wide range of environmental conditions.

In a number of cases, the equipment will be previewed a few days earlier at the IRE show in New York's Coliseum.

Among those at IRE, MB Electronics division of Textron Electronics, Inc., featured a new series of permanent ceramic magnet vibration exciters. According to the company, the use of a ceramic magnet, said to exhibit superior coercive force and operating life characteristics, is an industry first.

Utilizes Low-Power Amplifier

MB also unveiled a narrow-band sweep random motion system, first introduced in a technical paper before an IES meeting late last year. It is designed for random testing with low power instead of high power amplifiers. *(For more information circle EQ RSC "D.")*

Unique models of another type will be displayed by Associated Testing Laboratories, Inc., in Washington. One is the Econ-O-Line Mark II, a ½-cubic-foot (12"x12"x6") high-low temperature chamber with CO_2, to sell at under $300. The chamber has a range of —100° to +240° F and utilizes a United Electric indicating controller.

Also in the Econ-O-Line series will be a 18"x18"x18" chamber in the same temperature range but with humidity added. In this unit, liquid CO_2 is forced through coils for dehumidity, resulting, according to ATL, in a much less expensive chamber than one accomplishing the same purpose with mechanical refrigeration. *(For more information circle EQ RSC "E.")*

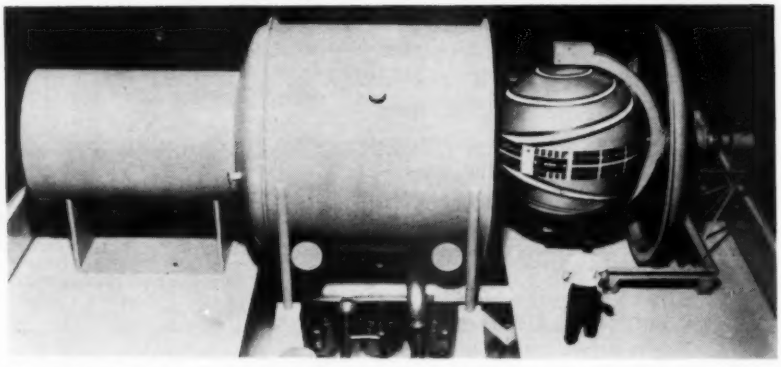
Variety of Equipment

At its IRE booth Tenney Engineering, Inc., exhibited a scale model of an orbital simulator it is also showing at IES. The simulator, for which Tenney has been awarded the prime contract, is for Chance Vought Corp.

Tenney will also feature its new, wide-band, high-intensity noise equipment for acoustic tests. Its Communication Measurements Laboratory subsidiary will share

(Continued on Page 13)

Close-Up of Space at the Sheraton-Park



This scale model of an orbital simulator for which it has been awarded a prime contract by Chance Vought Corp. will be displayed at the IES show by Tenney Engineering, Inc., Union, N.J. Capable of spinning test objects up to eight feet in diameter and 1,000 pounds in weight on two axes, the simulator will provide space thermal radiation leve's and solar spectral radiation of variable flux, Earth to Mars, and a special heat sink refrigerated to —320° F with liquid hydrogen. Pressure will be reduced to 1×10^{-7} mm Hg., or 1,100,000 feet.

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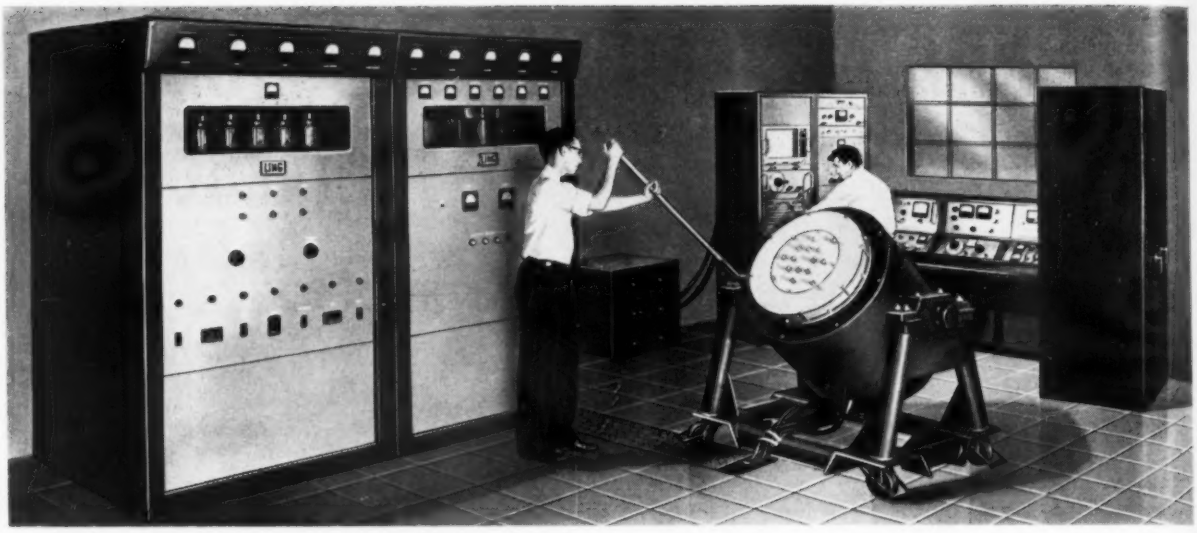

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30th Shock, Vibration Symposium to Study Transportation, Operational Environments

The 30th Symposium on Shock, Vibration and Associated Environments, sponsored by the Office of the Director of Defense Research and Engineering, will be held in Detroit, next Oct. 10-12. Transportation and packaging and extreme operational environments will be discussed in a parallel series of classified sessions.

In the area of extreme operational environments, sessions are planned around measurement and simulation of space environments, including pressure, thermal radiation and temperature and micrometeorites; use of the mechanical impedance concept in structure design and noise, correlation of laboratory tests and flight performance; shipboard shock problems; radiation phenomena, principally transient nuclear radiation, and large or unique test facilities for the simulation of extreme environments.

Sessions on transportation and packaging are expected to include such topics as measurement and definition of transportation environments; laboratory simulation of transportation environments; design of missile containers and transporters; isolation of packaged items and problems of package cushioning, and aerial delivery of supplies and equipment.

British SEE Also Elects; Meeting on Corrosion Set

As ballots were being cast in the election of officers of the Institute of Environmental Sciences in the United States, the Society of Environmental Engineers in England held its annual meeting on March 24. The retiring chairman was V. G. P. Weake, a founder of the two-year-old society.

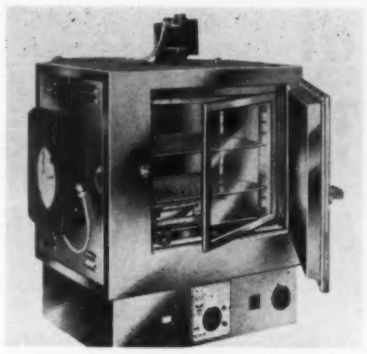
The First International Congress on Metallic Corrosion is scheduled to be held at Imperial College, London, April 10-15. On April 12 the SEE will sponsor a discussion at the college on "Climatic and High Vacuum Environmental Test Chambers," with papers by V. A. Austin and B. Adamson.

Shock Studies Discussed At Local Chapter Meeting

Shock phenomena was the subject of the Feb. 28 meeting of the Mid-Atlantic chapter of the I.E.S. held in Philadelphia. W. Stewart, Convair-San Diego, discussed "Shock Studies of the Hyge Shock Machine."

Gaffney of U. S. Testing Addresses Joint Meeting

H. Gaffney, associate director of research, United States Testing Co., Inc., Hoboken, N. J., addressed a joint meeting of the New York chapters of I.E.S. and S.E.S.A. and the North Jersey chapter of A.S.M.E. on March 6 at Stevens Institute, Hoboken. The topic was "Statistics as Applied to Experimental Testing."



Blue M's Temp-Humidity Cabinet to be seen at IES.

New Equipment

(Continued from Page 10)

the booth with the Acoustic, Aerospace, Environmental and Ground Support divisions.

Still another temperature-humidity cabinet (illustrated above) will be on display at IES in the Blue M Electric Company booth. Designed for MIL-202B, Method 106A, Steps 1-6, and Method 103A, Procedure 2, testing, the equipment incorporates Blue M's patented Power-O-Matic 60 Saturable Reactor Controls. A single reactor modulates the power to both the wet and dry bulb, without cycling, contacts or refrigeration. Tap water is used as the coolant. *(For more information circle EQ RSC "F.")*

Among West coast entries at the Sheraton-Park will be Rototest Laboratories, Inc.'s, Rotocon, a quality control complex wave vibration machine which monitors the performance of components and assemblies for final acceptance tests. This device was designed by Convair and is manufactured and sold by Rototest under exclusive license. *(For more information circle EQ RSC "H.")*

IES Meeting

(Continued from Page 10)

executive secretary, announced the dates as April 11-13, and the place as the Sheraton Towers Hotel, Chicago. It was in Chicago two years ago that the IES was born of a merger of the Institute of Environmental Engineers and the Society of Environmental Engineers.

Arthur B. Billet, executive vice president of the society, is general chairman of this year's meeting. He is with Vickers, Inc., Detroit. David Askin, of Frankford Arsenal, Philadelphia, and Raymond Yeager, of Chrysler Corp.'s Missile division, Detroit, are chairmen of the technical program. Norman Ponge, of Space-Tronics, Mineola, N.Y., heads the exhibits committee. A. S. Jenkins, of Emerson Research Laboratories, Silver Spring, Md., is registration chairman.

Minimization of Test Programs

By Proper Classification of Environmental Factors

by

Norman R. Garner, D. E. Hartvigsen and S. Roy Wood

Aerojet-General Corporation

From the constantly increasing severity and complexity of the environments to be mastered in deep-space probing comes a stream of ever more stringent requirement tor component reliability. Proper classification of environmental factors can keep the staggering number of indicated test programs within bounds and reduce appreciably the amount of time and money that must be committed to insure survival of our space vehicles.

WITH EVER DEEPER SPACE PROBES, more reliable components are needed for the vehicle to survive in attendant new sets of severe, complex environmental conditions. As the range of environmental conditions is extended, so developmental costs increase in the search for more reliable systems. Proper classification of environmental factors and use of statistical methods can effect large economic savings in test programs, provide assurance of maximum information from test results and allow efficient estimation of "operational reliability."

The almost infinitely large number of combinations of environmental factors can be condensed to manageable proportions by applying one or more of the following five principles:

¶ Establishment of mutually exclusive sets of environmental factors.

¶ Definition of the environmental periphery.

¶ Classification of environmental factors according to the effect of failure of the system on the direction of the development program.

¶ Classification of environmental factors according to the effect of failure of the system on operational performance.

¶ Scheduling of tests according to the method of detecting an environment effect.

Environmental Complexity and System Reliability

The need for more reliable components of rocket propulsion systems is related intimately to the expanding complexity of the environmental conditions in which these systems are stored, transported and ultimately consumed. Specifically, consider the impact of the new sets of environmental conditions on rocket component design, using igniters as an example.

Igniters were designed originally for operation at sea level, or at relatively low altitudes, and under little or no acceleration. In the new programs, however, igniters are required to perform under more stringent conditions and, when placed in second, third, or later stages of a space vehicle, to function efficiently in near-vacuum conditions after suffering the huge strains of acceleration and flight vibration.

Success can no more be expected with the earlier igniter designs than if the electronic equipment of a home television set were placed in a rapidly accelerating space vehicle. The components of the television set were designed to perform reliably under static conditions, not under severe dynamic conditions.

Reevaluation Required

Whenever an environment becomes more complex, the system must be evaluated under the new conditions and then redesigned, as required, to make it insensitive. It is evident, therefore, that developmental costs must increase.

Consideration of the environments a system will encounter is especially important when destructive tests are required, not only to estimate reliability of the system, but to determine causes of failure. Proper classification of environmental parameters and careful interpretation of test results can effect substantial economic gains, provide assurance of maximum information, and allow an efficient estimate of "operational reliability."

Test programs should be planned to enable cognizant engineering personnel to reach objective conclusions regarding the vulnerability of product design to environments met in the life cycle of a system. Experimental plans are already available in the literature to assess initial system designs on a statistical basis. Before assigning environmental variables to these experimental patterns, it will be helpful to refer to the environmental complex as the *n*-factor space or environmental parametric space.

Concept of Environmental Parametric Space

Environmental parametric space can be considered simply as a response surface having as many dimensions as there are distinct environmental factors acting on a system during its life cycle. The environmental factors of temperature, altitude and acceleration, for example, constitute a three-dimensional space or response surface. A point on

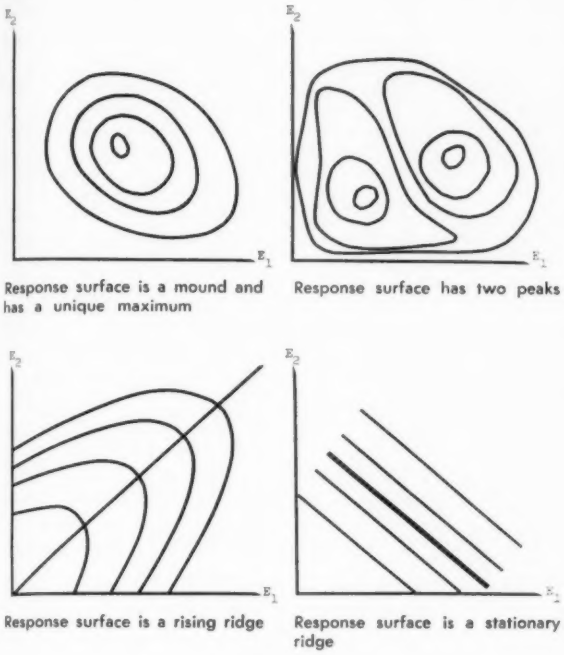

Response surface is a mound and has a unique maximum
Response surface has two peaks
Response surface is a rising ridge
Response surface is a stationary ridge

Figure 1

Four Possible Contour Surfaces for Environmental Factors E_1 and E_2

this surface is defined when a level or value is specified for each of three factors, e.g., 70° F temperature, sea level altitude, and zero gs acceleration.

Four different types of response surfaces are shown for two environmental factors, E_1 and E_2, in Figure 1, where every point on a contour line represents the same value of the response. A response can be any measurable output, such as burning time, thrust, specific impulse, pressure, energy, or even an estimate of reliability. Only three dimensions can be represented geometrically, but the concept of environmental parametric space holds for the general case of *n*-dimensions, which must be imagined.

The definition of environmental parametric space is complicated by the infinite number of paths that a rocket system can take during its life cycle. For example, with only four points, P_1, P_2, P_3 and P_4, there are 24 different orders in which the four points can be arranged.

A Way of Envisioning It

One way of envisioning an environmental parametric space is to list the various routes an individual rocket motor might travel from fabrication to end use. A typical life-cycle route might be: packaging at vendor, loading on transport vehicle, transportation to customer receiving facility, unloading and inspection, storage, removal from storage and loading on transport vehicle, transportation to field storage, unloading and inspection, placement in field storage, removal from field storage followed by pre-flight checkout, loading on ground, ocean craft, or aircraft launcher and, finally, launch.

Thus, there is a prohibitively large number of possible life-cycle sequences, the number being a product of the various possibilities at each stage of the life-cycle sequence. For example, in packaging and loading a rocket motor on the transport vehicle, there are two possibilities: rough handling (including perhaps accidental drop) and no rough handling. In the transportation phase, there are four modes of shipment: rail, truck, ocean craft and aircraft. For unloading at customer receiving facility, there again is the dichotomous situation of rough handling or no rough handling. To this point alone there is an accumulative total of 2 x 4 x 2=16 combinations or routes. The total accumulative number would be infinitely large if the launching phase were analyzed in the same manner.

A further complication is that the values or stress levels of certain environmental factors, such as temperature, may change continuously, while other factors, such as altitude, may remain relatively constant during most of the rocket's life cycle. On the other hand, when units are transported, and particularly when they are launched into space, large and sometimes rapid changes occur in the values of such environmental factors as vibration, temperature, altitude and acceleration.

Parametric Space Is Dynamic

The environmental parametric space is observed to be dynamic. At any time *t* in the life cycle of a rocket unit, there are *n* environmental parameters acting upon it. Each factor is imposing a level of stress upon the rocket unit which adds in some cases and compensates in others to yield an over-all composite or effective stress level. Each component in the rocket system will not be affected identically by the resultant composite stress because of differences in component location and in structural characteristics.

Furthermore, as the level of an environmental factor changes the composite stress imposed upon a rocket system also varies. The result of these dynamic conditions is that a component is subjected to a stress spectrum in

Garner Hartvigsen Wood

Norman R. Garner has many publications to his credit devoted to the use of statistics in all phases of industrial enterprise. A math graduate of the University of Rochester, he took his master's in statistics at North Carolina State College in 1951. Since 1957 he has been with Aerojet-General in Azusa, Calif., as a technical specialist in the application of statistics to research reliability and quality control programs.

D. E. Hartvigsen is associate manager of corporate reliability at Aerojet-General. With two mathematics degrees, a B.S. from Utah State Agricultural College in 1938 and an M.S. from Iowa State in 1941, he spent six years with the Navy as a physicist, first in the degassing program at Bayonne, N. J., and later in aerodynamic testing of rocket models at China Lake, Calif. Then he returned to his chosen field, applied statistics, from 1947 to 1955 at NOTS, China Lake, and since 1955 with Aerojet-General, specializing in the application of statistical concepts to weapons development and testing programs.

S. Roy Wood, a New Yorker, has been statistical consultant with Aerojet-General's Azusa plant for the past two years. Holder of a bachelor's degree and a master's from the City College of New York in statistics, he is currently working on his doctorate in the same field at New York University. Before his association with Aerojet-General, he was with the Celanese Corporation of America, specializing in statistical design and analysis in plastics research. He has taught statistical quality control at Seton Hall University and at the Citrus College.

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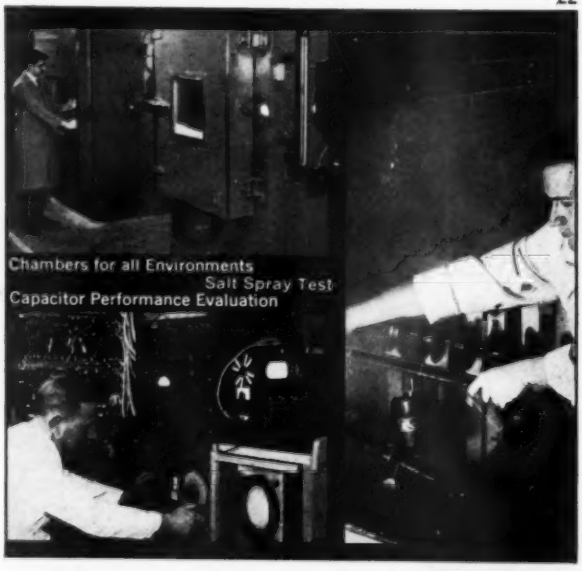

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its life cycle that is unique for that component. Although the stress spectra of identical components in the same rocket unit will vary, they are likely to be more similar than the stress spectra of two identical components placed in different rocket units. In short, the stress spectrum acting on any one rocket unit is determined by the "trajectory" the unit travels in its environmental parametric space.

It is evident that, as a rocket propulsion system moves through and is finally consumed in a multi-dimensional environment, the number of combinations of environmental conditions is infinite. Therefore, it is not possible in rocket-testing programs to test units under all conceivable factor combinations. It further follows that, because the spatial environment is so complex, methods must be devised for condensing the infinitely large number of combinations of environmental factors and sequences of application to something manageable to design an optimum testing program. Consequently, the establishment of realistic design objectives can be accomplished by an accurate knowledge of the environment through which the equipment is stored, transported and expended, and by proper classification of environmental conditions to make feasible the environmental test program.

Reduction of Environmental Factors

The first and most important method of bringing the number of test combinations to manageable proportions is to prepare a list of mutually exclusive sets of environmental factors. Here a proper enumeration of mutually exclusive sets of environmental variables can be very profitable. For example, 1,024 systems are required to test all possible combinations of 10 factors each at two levels. If three environmental variables are not mutually exclusive and can therefore be regarded as one group, then only $7 + 1 = 8$ factors need be tested. This reduces the testing costs by one fourth, since only 256 systems are required.

Non-mutually exclusive sets of environmental factors occur, for example, when specifications require the following tests: (a) jolt and jumble, (b) longitudinal vibration and (c) horizontal vibration. They may be classified as a distinct generic environmental variable, vibration. Another example of a generic classification is weather. "Dry weather" consists of sunshine, heat, sand and dust. Humidity, rain, and salt spray can be classified as "wet weather."

Many testing programs are excessively large because mutually exclusive sets of environments are not enumerated. For example, the environmental factors encountered in the testing of most rocket-powered space vehicles can be compressed profitably into a compact list of 10 categories:

¶ Vibration: mechanical and acoustical.
¶ Mechanical shock: accidental drop and rough handling.
¶ Temperature cycle.
¶ Weather: rain, salt spray, humidity, sand and dust, sunshine.
¶ Aging.
¶ Radiation: gamma and neutron.
¶ Cosmic bombardment.
¶ Acceleration.
¶ Firing altitude.
¶ Firing temperature.

The economic gains can be staggering if a developmental program is based on mutually exclusive sets of

environmental factors and is designed and analyzed using modern statistical procedures.

Determination of Environmental Periphery

Even further savings can result if the environmental spectrum of each factor is interpreted properly. There is an infinite number of ways a rocket motor can move through its environmental parametric space during its life cycle, and the various alternatives can be reduced to a practicable level of testing by studying the environmental spectrum of each variable and delineating the peripheral or extreme conditions.

In applying this concept, the stress levels for each category are ranked according to severity. The least and most severe stress levels are selected and are designated as the environmental periphery, and environmental parametric space has shrunk to a manageable periphery. This approach is sensible since it is not necessary to describe the response surface over the entire environmental envelope, but merely to pinpoint the environmental limits influencing the operation of the system. An example of a test program established using the concept of environmental periphery is shown in Table I. Six environments, A to F, can be studied, each at two levels of stress. The experimental plan or layout is called a factorial design.

A test program based on environmental peripheries can be reduced even further by running only a portion of the entire experiment. Thus, if $2^{10}=1{,}024$ tests are a prohibitively large number of combinations, ten factors can be evaluated by doing a mathematically balanced fraction of the total program. In fact, for some experiments, a 1/32nd replicate ($1/32 \times 2^{10}$) or 32 tests may be sufficient.

Fractional factorial designs that are used frequently have been collected in a Department of Commerce publication, *Fractional Factorial Experiment Designs for Factors at Two Levels*, issued April 15, 1957. If the proper fraction is selected, it is possible to assess mathematically the sensitivity of the rocket to the stresses imposed by the different environmental factors under study. Although some higher-order interactions are sacrificed, fractional factorials can investigate selected interactions among the factors, as well as the reproducibility of rocket motor behavior. The most important advantage in carrying out only a small part of the program is obviously that the number of test units expended is pared to a minimum, resulting in savings of both time and money. Experimental designs based on full and fractional factorials have been presented at recent Western Regional American Society for Quality Control conferences.*

Effect of Failure on Direction of Program

After establishing mutually exclusive sets of environmental factors and defining the periphery of each variable, a further reduction in the size of a test program is possible by classifying environmental parameters according to how the developmental program would proceed if failure occurred. Environmental tests which have the same impact on the development effort, if unsuccessful, can be combined and run as a group. For example, if failure oc-

*Hartvigsen, D. E., and Lloyd, D. K., "The Application of Statistical Test Designs to Qualification Testing of Rockets and Guided Missiles," San Francisco, Sept. 9-10, 1957; Garner, N. R., and Hartvigsen, D. E., "Experimental Designs in Development, Proof and Qualification Testing of Rocket Motors," San Diego, Aug. 7-8, 1958, and Garner, N. R., "Introduction to Experimental Designs for Investigating Reliability, Response and Wearout of Complex Expensive Systems," Phoenix, October 23-24, 1959.

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DESIGN: Top opening_____(or) Front opening_____
INSIDE DIMENSIONS: left to right_____
front to back_____top to bottom_____
TEMPERATURE RANGE DESIRED:
from +_____°F to minus_____°F
PULL DOWN TIME DESIRED
from +_____°F to −_____°F in_____minutes
CHAMBER WITH HEATING CYCLE: Yes_____No_____
Heat Up Time from ambient (+80°F) to +____°F in____minutes
FORCED AIR CIRCULATION INSIDE OF CHAMBER: Yes____No____
INSTRUMENTATION: Indicating_____
Recording_____Programming_____
POWER REQUIREMENTS:
_____volts_____phase_____cycle
INTERIOR LIGHT: Yes____No____ CASTERS: Yes____No____
VIEWING WINDOW: Yes____No____Size_____
TERMINAL PANEL: Yes____No____
Number of Terminals_____Size_____
PORTHOLES: Yes____No____
Quantity_____Size_____
CHAMBER WITH HUMIDITY CYCLE: Yes____No____
CHAMBER WITH ALTITUDE CYCLE: Yes____No____
to_____Feet
COMMENTS: _____

Cut out and Mail

SEND YOUR QUOTATION TO:

NAME_____
MY NAME_____
COMPANY NAME_____
STREET ADDRESS_____
CITY_____ZONE____STATE_____
Have Your Representative Call Yes____No____

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curred on a high-altitude igniter because of acceleration or vibration, the reorientation of the development program would be identical.

Therefore, it is not necessary in the experimental phase of the project to specify which one of the environmental factors is the culprit since, if either caused failure, the redirection of the program essentially would be the same. An experimental program can be cut in half by using this rationale. Although fewer trials are run, the conclusions are scientifically valid, and there is no real loss of information about the environmental factors.

Operational Effect of Failure

Another way to reduce the amount of testing is to classify operational effects of environmental factors into the dichtomous groups: (a) causes failure and (b) causes efficiency loss. For example, an environmental factor such as shock can cause a system to fail completely but one such as storage may cause only a loss of efficiency. If an environmental factor that can cause failure is combined with one that only will weaken the system, fewer trials will be required, provided that the failure can be repaired so that a retest is possible.

For example, the testing program shown in Table I calls for $2^6=64$ cells or test combinations. Now suppose that environmental factors A, B and C can cause complete failure of the system and that environmental variables D, E, and F cause only degradation of the system. Further suppose that a failure by A, B, or C is repairable so that the system can be retested without loss of information about D, E, and F. Then, only a total of 16 experimental cells are necessary, eight for each of the two environmental categories, as shown in Table II, instead of the 64 combinations of Table I. It is noted, however, that reduction in the number of test cells may not be possible if there is an interacting effect between A, B, C and D, E, F.

Method of Detecting Environmental Effect

Finally, a very useful classification of environmental factors is by the method employed in detecting an effect. For some systems lack of performance can be detected by visual examination or by non-destructive techniques, such as X-ray or ultrasonic inspection. If failure can be ascertained without destruction of the system, experiments can be superimposed on one another, again provided the failures are repairable. Tests that are non-destructive are performed first. After repair, if failure has occurred, the destructive tests are scheduled. This approach can reduce drastically the number of units required, thereby assuring significant economic savings.

An Application: Alclo Igniters

These various principles were considered in establishing the component proof-testing program of the plastic-cased high-altitude Alclo igniter developed by the Aerojet-General Corporation. Here is a brief summary of the program as an application of the concept of proper classification of environmental factors.

The objectives of the program were two-fold:

(1) To present certified evidence of acceptable performance and of insensitivity to environmental changes. Estimates of "operational reliability" and performance were to be obtained for both attributes and variables measurements.

(2) To provide the maximum amount of information for further direction of the development program at

TABLE I

Environmental Periphery of Test Program

For Six Variables (A, B, C, D, E and F), Each Studied at Two Levels of Stress

			A_0				A_1			
			B_0		B_1		B_0		B_1	
			C_0	C_1	C_0	C_1	C_0	C_1	C_0	C_1
F_0	E_0	D_0	1*	2	3	4	5	6	7	8
		D_1	9	10	11	12	13	14	15	16
	E_1	D_0	17	18	19	20	21	22	23	24
		D_1	25	26	27	28	29	30	31	32
F_1	E_0	D_0	33	34	35	36	37	38	39	40
		D_1	41	42	43	44	45	46	47	48
	E_1	D_0	49	50	51	52	53	54	55	56
		D_1	57	58	59	60	61	62	63	64

*The numbers in the cells, Tables I-III, are the environmental combinations required to be tested.

TABLE II

Reduction of Factor Combinations Through Classification of Environmental Factors by Operational Effect of Failure

Environmental Variables Causing Failure of System

	A_0		A_1	
	B_0	B_1	B_0	B_1
C_0	1*	2	3	4
C_1	5	6	7	8

Environmental Variables Causing Efficiency Loss of System

	D_0		D_1	
	E_0	E_1	E_0	E_1
F_0	9*	10	11	12
F_1	13	14	15	16

*The numbers in the cells, Tables I-III, are the environmental combinations required to be tested.

TABLE III

Experimental Design for Component Proof-Testing Of High-Altitude Plastic-Cased Alclo Igniter

	F_1S_1	F_1S_2	F_2S_1	F_2S_2	Row Totals
W_0	R_1 20*	R_2 20	R_3 20	R_4 20	80
W_1	R_2 20	R_3 20	R_4 20	R_1 20	80
W_2	R_3 20	R_4 20	R_1 20	R_2 20	80
W_3	R_4 20	R_1 20	R_2 20	R_3 20	80
Column Totals	80	80	80	80	Grand Total 320

F_1—Fire at 0°F
F_2—Fire at 120°F
S_1—Soak at -65°F
S_2—Soak at 160°F

W_0—No weather treatment
W_1—Humidity
W_2—Humidity, fungus
W_3—Humidity, fungus, salt spray

R_1—Shock at -65°F
R_2—Shock at -65°F (acceleration and vibration**)
R_3—Shock at 160°F
R_4—Shock at 160°F (acceleration and vibration**)

*The numbers in the cells, Tables I-III, are the environmental combinations required to be tested.

**Acceleration and vibration are at the firing temperature.

minimum cost. Thus, causes of any unsatisfactory performance had to be determined.

The experimental design that was established is shown in Table III. Of 400 igniters allowed for the experiment, 320 were assigned to specific environmental combinations, and 80 were available for further investigation of indicated trouble areas, if any. Environmental peripheries were determined for firing temperatures (0° F and 120° F), soaking temperatures (—65° and 160° F), and shock temperatures (—65° F and 160° F).

Weather Divided into Four Levels

Weather could have been handled similarly, i.e., classified into the dichotomous groups "weather" (humidity, fungus, salt spray) and "no weather treatment," but because information was required specifically on the effects of humidity and fungus, the "weather" category was broken down into four levels.

Acceleration and vibration were combined into a mutually exclusive environmental set, being treated as part of the generic environment, motion. These environments can always be applied together, because redirection of the development program is similar if failure is due to either factor, and it therefore is not necessary to identify the specific environmental variable causing failure. Thus, application of three of the principles of proper classification of environmental factors reduced appreciably the number of environmental combinations required in the test program. Aside from the savings in time, money and units, management problems in administering a large, cumbersome program were avoided.

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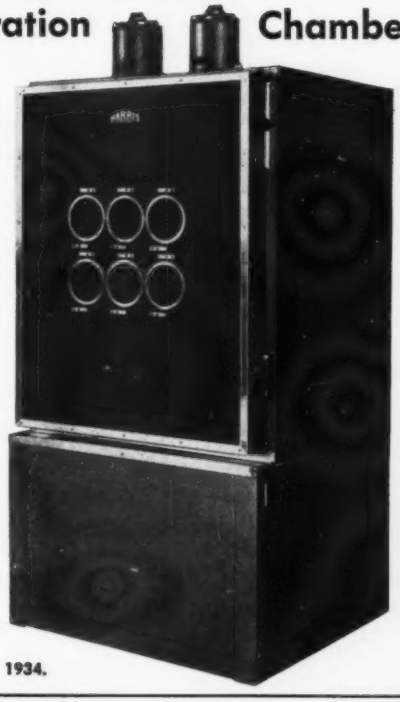

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ENVIRONMENTS IN USE...

Insuring the Success of Avco's Minuteman Mark 5

Shattering all records established in the research and development of long range ballistic missiles, an Air Force Minuteman ICBM rose from Cape Canveral on February 1 last on a successful 4,600-mile test. Never before had such a missile gone all the way to the predetermined impact area on the first flight. Never before had all the stages of a multi-stage ICBM functioned on the first flight. And, never before on a first flight had the guidance system placed the re-entry vehicle on target.

The Minuteman's re-entry vehicle was the Avco Mark 5. It was designed at Avco's Research and Advanced Development Division, Wilmington, Mass., where it underwent a rigorous environmental testing program before being delivered to Cape Canaveral for the historic flight.

The objectives of the re-entry vehicle testing program were:

¶ To determine the ability of the re-entry vehicle structure to withstand the pre-flight, powered flight and re-entry environmental conditions.

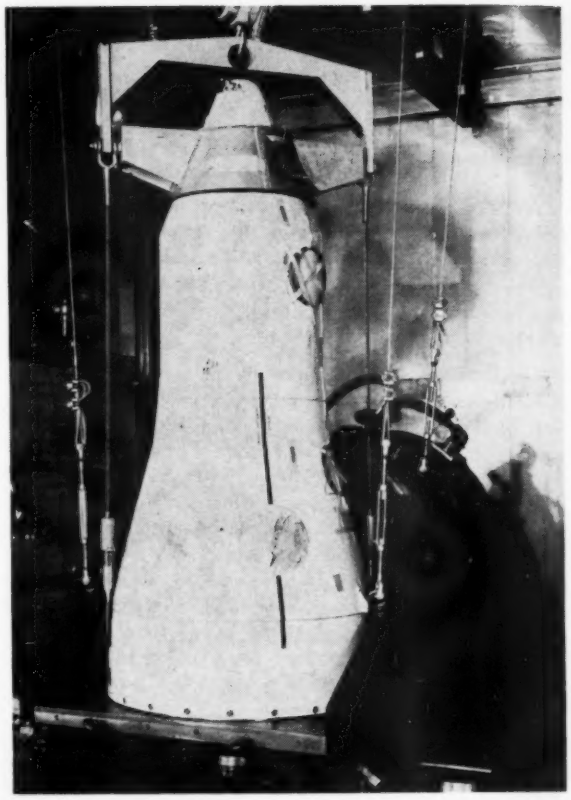
¶ To determine the functional capability of operational and non-operational equipment both during and after application of simulated flight environmental conditions.

¶ To determine the design adequacy, integrity and ability of the system to conform to design requirements.

During the first phase, certain select components of the over-all system were subjected to a series and combination of operational and environmental tests for conditions anticipated in the factory-to-launch-to-target sequence.

In the factory-through-launch phase, environments such as handling shock, transportation vibration and shock, storage and transportation temperature extremes and storage humidity, fungus, salt spray, and sand and dust were anticipated. In the pre-launch period at the complex, climatic extremes and electromagnetic radiation were thought to be present. During launch and powered flight, increased temperature, vibration, acoustic noise and acceleration conditions were sure to be imposed on hardware. In non-powered flight, there are altitude extremes. And finally upon re-entry extremely high temperatures, vibration, acoustic noise and deceleration loading are present.

THE MARK 5 RE-ENTRY vehicle for the Air Force's Minuteman is shown in Avco's acoustic chamber, where the sound reaches approximately 143 decibels. Technicians are placing three microphones to pick up the sound pressure level in the chamber, which simulates the acoustic noise environment of the missile firing.



MARK 5 MINUTEMAN ICBM re-entry vehicle in position for combination temperature and vibration tests at the Avco Corporation's Research and Advanced Development division's environmental lab.

Many of these environments were applied to components through laboratory simulation.

In Phase 2 of the test program, the same simulated environments were applied as applicable to devices of the sub-system level. Phase 3 saw, in addition to environments applied singly, the combined environments of vibration-temperature-altitude and g loading imposed on the re-entry vehicle.

This combination was applied for three axes of vibration. For the longitudinal application, the vehicle was suspended horizontally in the temperature chamber and attached to a vibration exciter-table with a dish-like vibration fixture. A conical fixture, designed to simulate launch acceleration loading, was attached to the vehicle and exciter fixture, and the entire vehicle was soaked at −350° F and a sinusoidal vibration, at a constant octave sweep rate, was applied from 10 to 2000 cps for 25 minutes. Following this vibration test, the temperature was raised to 160° F, the pressure was reduced to .044 inches of mercury, and the vibration test was repeated from 2000 to 10 cps.

After the sweep test, sinusoidal vibration was applied at the frequency of maximum transmissibility of the vehicle, and the separation mechanism was functioned. During this period, continuous accelerometer readings were recorded and the data was used to determine the dynamic characteristics of the re-entry vehicle as it separated. #

DIRECTORY OF EXHIBITORS

I. E. S. SHOW

Sheraton-Park Hotel, Washington, D. C. • April 5-7, 1961

Booth No.	Exhibitor
10	Allied Research Associates
43-44	American Instrument Co., Inc.
1	American Research Corporation
47-48	Associated Testing Laboratories, Inc.
23-24	Avco Research & Advanced Development Division
31	B & K Instruments, Inc.
100-101	Barry Controls Division, Barry Wright Corp.
69	Bemco, Inc.
58	Bethlehem Foundry & Machine Co.
30	Blue M Electric Co.
70-72	Cardox Division, Chemetron Corp.
6	Chadwick-Helmuth Co.
54	Cincinnati Sub-Zero Products
107	Columbia Research Laboratories, Inc.
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62	Endevco Corporation
27	ENVIRONMENTAL QUARTERLY
7	Gruenberg Electric Co., Inc.
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19-20	Gulton Industries, Inc.
77-78	High Vacuum Equipment Corp.
73	ITT Industrial Products Division
74	Kistler Instrument Corp.
87-88	Ling Electronics
49-50	Liquid Carbonic Division, General Dynamics Corp.
11-12	MB Electronics
25-26	Minneapolis-Honeywell Regulator Co.
63	Missimers, Inc.
99	National Research Corp.
59-60	Optron Corporation
15-16	Pure Carbonic Co., division of Air Reduction Co., Inc.
37-38	Research, Incorporated
108	Rototest Laboratories, Inc.
109-110	F. J. Stokes Corporation
80-81	Strong Electric Corp.
85-86	Tenney Engineering, Inc.
41	Test Engineering
39	Unholtz-Dickie Corporation
90	United States Testing Co., Inc.
13	United Testing Laboratories
34-36	Wyle Laboratories

LITERATURE FOR ENVIRONMENT...

Harris Manufacturing Co., Inc., Cambridge, Mass., has a four-page catalog folder on temperature and humidity chambers for environmental testing. Standard models have capacities from 2 to 10 cu. ft. and temp ranges of —100° to +250° F. Equipment is protected against overpressure resulting from electric or water failure and against loss of refrigerant. **(Circle EQ RSC #38.)**

• • •

Gulton Industries, Inc., Metuchen, N. J., has issued preliminary Bulletin A24 on its Glennite portable calibrator, Model LT-1010, used for calibration checks on vibration and pressure transducers in the field. **(Circle EQ RSC #39.)**

• • •

B & K Instruments, Inc., Cleveland, has a 28-page, illustrated pamphlet in three languages describing electrical and mechanical performance characteristics of its model 4290 high frequency calibration exciter. **(Circle EQ RSC #40.)**

• • •

Central Scientific Co., Chicago, has a new 14-page illustrated booklet giving full details on the Cenco Hyvac S14 mechanical vacuum pump for industrial and laboratory applications. The S14 is rated at 140 liters per minute at atmospheric pressure and is guaranteed to pump down to 10 microns. **(Circle EQ RSC #41.)**

• • •

Columbia Research Laboratories, Woodlyn, Pa., has issued a bulletin describing true compression-type accelerometers for shock and vibration testing of missiles and airborne vehicles. **(Circle EQ RSC #42.)**

• • •

NRC Equipment Corp., Newton Highlands, Mass., has prepared an eight-page condensed catalog of its high-vacuum components and equipment, from valves to altitude chambers. **(Circle EQ RSC #43.)**

• • •

Industrial Acoustics Company, Inc., New York, offers an engineering data sheet showing uses of its standard acoustic panel components in conjunction with doors, windows, ventilation systems, and so forth, for quiet rooms, quality control rooms and other controlled acoustic environment enclosures. **(Circle EQ RSC #44.)**

• • •

Marquardt Corporation, Van Nuys, Calif., has issued a color brochure on its new SUE (sudden expansion) burner/heater for structural testing, air heating for sound generation and other applications. It is capable of stable burning operations at temperatures to 5,600° F and pressures to 1,000 psi. **(Circle EQ RSC #45.)**

Government Publications

Almost daily the U. S. Department of Commerce releases a number of technical reports for use by industry. These documents are sold through the department's Office of Technical Services, Washington 25, D. C. Here are some recent releases and their prices:

The ARDC Model Atmosphere, 1959, by R. A. Minzner, K. S. W. Champion and H. L. Pond, Air Force Cambridge Research Center, gives earth's atmosphere up to 700 kilometers, based on new rocket and satellite data, and revises 1956 figures above 53 km. 151 pages. Order No. PB 161305, $2.75.

Temperature Conversion Tables, by W. A. Brodhecker, U.S. Naval Avionics Facility, Indianapolis. Quickly and easily converts —100° to +300° Fahrenheit to Centigrade with an accuracy to three decimal points. Second and third place accuracy in converting Centigrade to Fahrenheit depends on interpolation. 84 pages. Order No. PB 161354, $2.25.

Steady State Damped Vibrations and Stability of a Class of Nonlinear Discrete Systems, by S. T. Chow and P. R. Sethna, University of Minnesota for WADD. Part of an Air Force study of materials analysis and evaluation techniques. 52 pages. Order No. PB 161748, $1.50.

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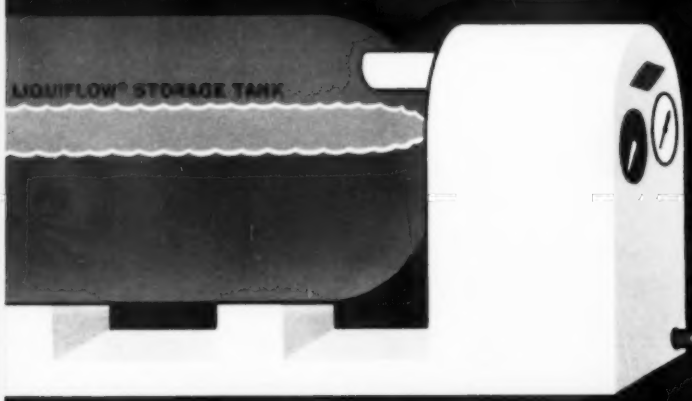

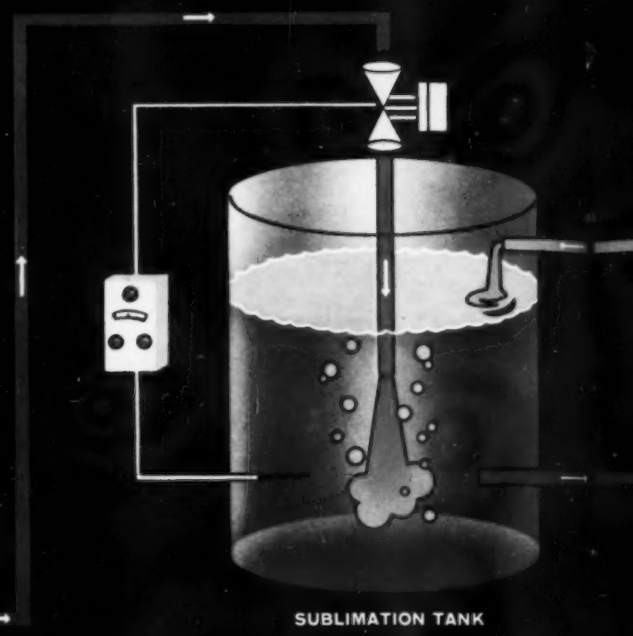

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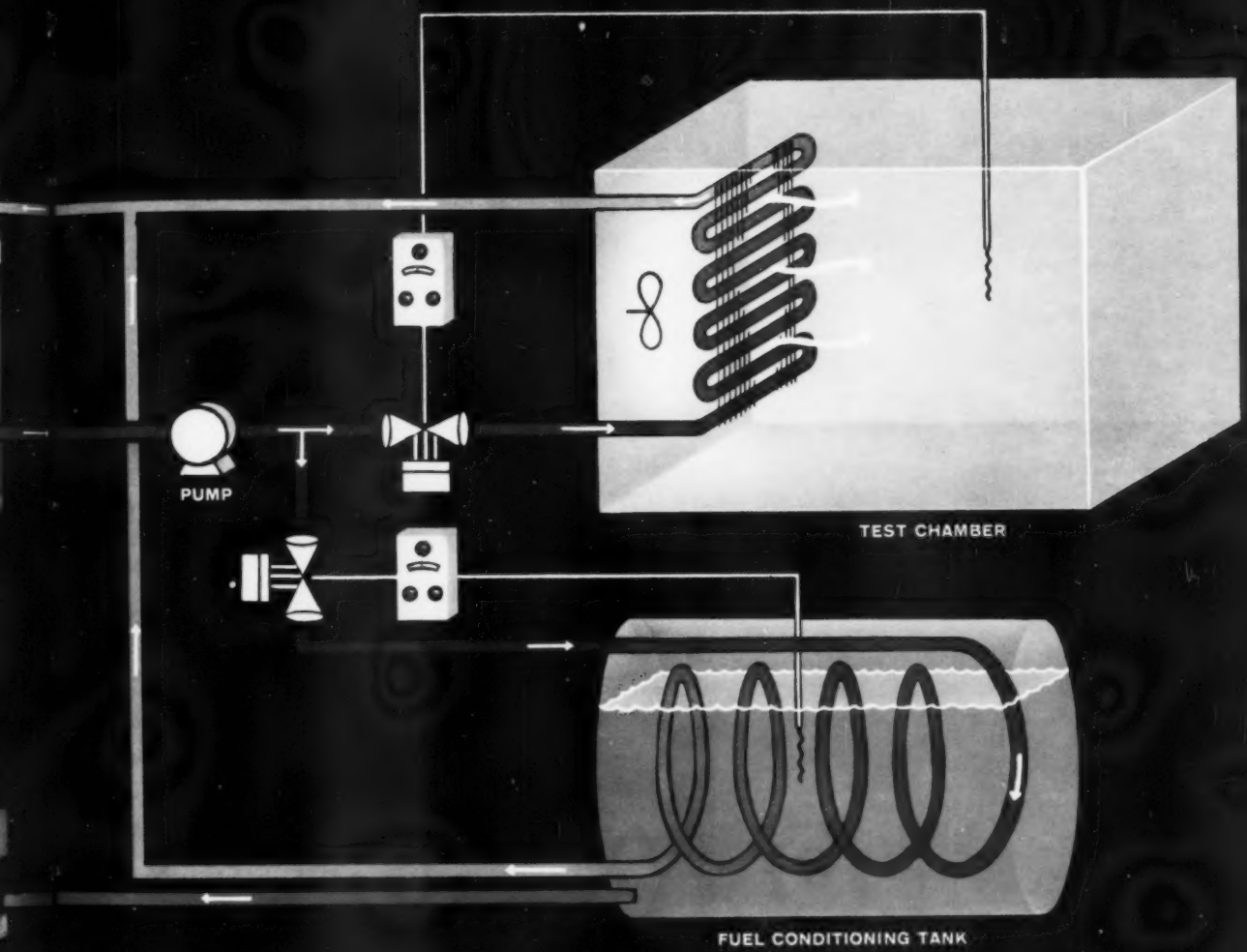

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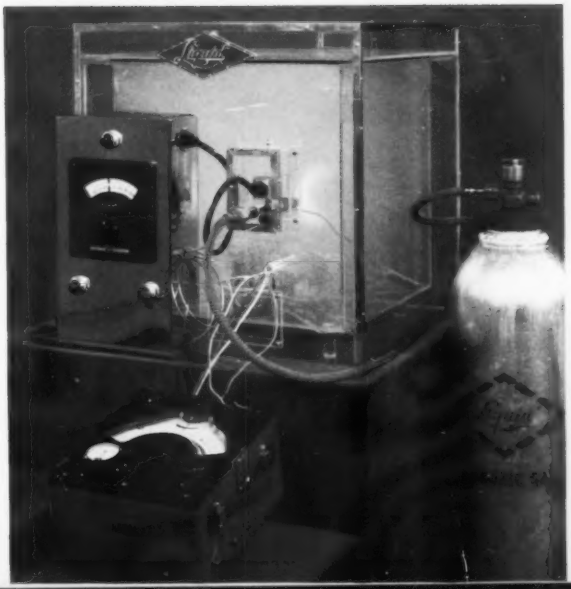

Environmental Want Ads

Rates: $5 (minimum) for three lines, $2 per line additional. "Situation Wanted" ads free (except for reply box number) to those who can reasonably expect to find employment in the environmental industry, but prescribed form must be followed. First three lines free to those who write own "Situation Wanted" ads. Reply code number $2 extra but no charge for handling replies. Payment in full with copy, except from recognized agencies.

Deadline for July, 1961, issue is June 10, 1961. Send order, copy, payment and all inquiries to Environmental Want Ads, Environmental Quarterly, 252-46 Leeds Rd., Little Neck 62, N.Y.

For free "Situation Wanted" ad give only following information in this order: Job title (two permitted), age (if desired), degrees, recent experience, salary desired, where you prefer to work and name and address. (Last two will be withheld if reply code is used.)

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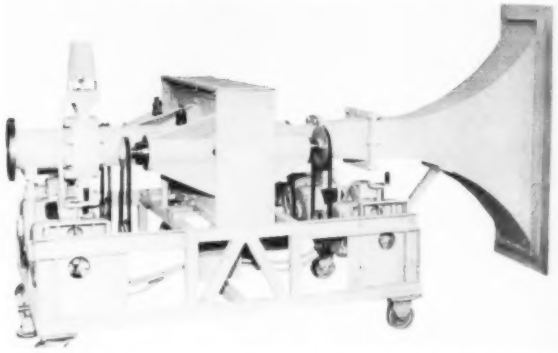
NEW PRODUCTS...

A "Reader Service Card" requiring no postage is bound into this issue for the convenience of those desiring additional information on new products, new literature (Page 21) and other announcements. It is keyed in the text as "EQ RSC."



Tenney Engineering, Inc.'s Stentor 205, claimed to be the world's most powerful wide-band (20-16,000 cps) noise generator. (For more information circle EQ RSC "A.")

SPOTLIGHT ON:

Noise Generator

Tenney Engineering, Inc.'s, new high-intensity wide-band noise generator is a siren, a form long known as an efficient generator of sound. For example, when it generates a square wave, 40% of the available energy is converted into sound, and a sinusoidal pulse may be generated at 30% efficiency. These compare well with lower efficiencies common to other types of systems.

Until recently sirens have been limited to single rotors, which generated such relatively simple wave forms as rectangular, trapezoidal, or sine functions. The Tenney siren series utilizes several overlapping rotors with variable pulse openings. This allows for a sequence of rectangular pulses to be generated and for varying both the pulse width and the distance between pulses for completely random excitation. By replacing the variable rotors with a stator and a symmetric rotor, sine pulses may be generated with the same basic equipment.

Many investigations have shown that actual noise sources approach being random, and that the most exact laboratory simulation therefore requires a random noise generator. Since sinusoidal testing often exposes a test specimen to abnormal environments, that type of test requires more costly and vigorous methods and analyses of results which, in most instances, must be substantiated by "proof-testing" in a random environment. The overlapping rotors permit the Tenney siren series to approach this same randomness, and sinusoidal noise can also be generated if required.

Capabilities

The three basic Tenney models are capable of generating high-intensity wide-band noise under conditions shown in Table 1.

Data from existing models is shown in Table 2 to illustrate sound pressure level capabilities in large test volumes.

SITUATIONS AVAILABLE

ENGINEERS-PHYSICISTS

Product Engineer—responsible for pilot production run on new products. 5 yrs exp. in design, testing and mfg. preferably in electronics. ME, EE or equivalent.

Development Engineer—design, build and test electronic circuits. 3-4 yrs. R&D exp. in instrument amplifiers, etc. BS, EE.

Project Engineer—R&D on pressure transducers and development of mechanical impedance measuring devices. BS in ME, EE or physics. 5 yrs. exp. in instrument design.

Physicist—Ph.D, 28-30 with industrial exp. in solid state or semi-conductor work with some device background.

These positions are at Endevco's Pasadena headquarters.

Send resume to Personnel Dept. Endevco Corporation, 161 E. California Blvd. Pasadena, California.

Data from existing models and requirements from future or proposed models show that high sound pressure levels are attainable up to 20,000 cps and that the low frequency is a function of horn and chamber frequency limitations. The lowest design frequency, to date, has been 26 cps. All models exhibit relatively rich, low frequencies, even with adverse chamber dimensions.

Existing or proposed model design frequencies are shown in Table 3.

The spectrum of the noise generators compares with jet and rocket engine spectra, and peaks in the desired frequency range.

Peak to RMS

The Tenney sirens have the advantage of providing peak excitations as high as 17 times the rms value whereas electro-mechanical devices are generally limited to sigmas (ratio of peak to rms) of 3. The higher peak value closely simulates actual jet and rocket noise spectra.

High-intensity wide-band noise can be maintained as long as the compressor unit can supply air, and for this reason, the Tenney siren is equipped with controls for rotor speed, airflow and horn loading.

Three types of cost are involved in the expense of a test or test series: Initial cost, testing expenses and maintenance expenses.

Initial cost covers not only that of the noise generator but also all auxiliary equipment necessary to operate and maintain it. Because of the low air flow required, Model 203 is adaptable to most plant air supplies, Models 204 and 205 require 600 cfm and 6000 cfm compressor systems, respectively. Most large organizations already have these capabilities.

Test expenses are cut by savings in time of test run and elimination of proof testing and of elaborate sinusoidal testing analyses. Maintenance expenses are very low by virtue of siren design, absence of paper or wire components and of intricate support equipment and a bare minimum of recalibration effort.

Model	PSIG	CFM	Acoustic Watts	Acoustic PWL (re 10^{-13} Watts)
203	30	60	100	150 db
204	30	600	1,000	160 db
205	30	6000	10,000	170 db

TABLE 1

Model	PSIG	CFM	Type of Chamber	Chamber Volume	Overall SPL (re 0.0002 dynes/cm 2)
203	30	60	Reverb't	27 cf.	145 db
204	30	600	Reverb't	64 cf.	155 db
205	40	6000	Plane-Wave	64 cf.	168 db
205	40	6000	Reverb't	192 cf.	163 db
205	40	6000	Reverb't	64 cf.	165 db

TABLE 2

Model	Lower Design Frequency	Upper Design Frequency	Intensities
203	100 cps	9,600 cps	high
203	200 cps	10,000 cps	high
204	150 cps	10,000 cps	high
204	26 cps	3,400 cps	high
205	80 cps	12,000 cps	high
205	75 cps	16,000 cps	high
205	150 cps	10,000 cps	high

TABLE 3

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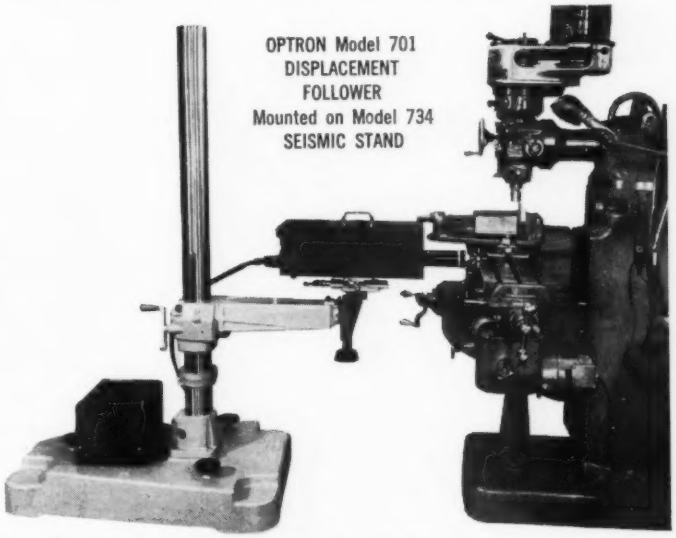
OPTRON Model 701 DISPLACEMENT FOLLOWER

Measures vibration of mill table or any other moving object without making physical contact. Response is flat to 3 KC. Displacement range 12 microinches (.000012") to 2 inches. Displacement appears as peak to peak voltage on readout voltmeter or oscilloscope, the latter also displaying the waveform of the motion.



OPTRON Model 701 DISPLACEMENT FOLLOWER Mounted on Model 734 SEISMIC STAND

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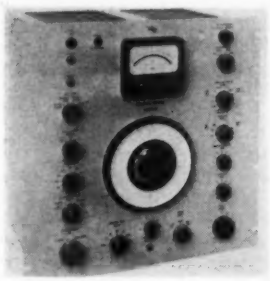
AUTOMATIC VIBRATION EXCITER CONTROL



Model N572, by MB Electronics, a division of Textron Electronics, Inc., maintains constant acceleration or displacement at the vibration exciter as frequency changes. Transfer of control function is also automatic. Safety features include a warning light which is activated when certain critical settings cannot be safely changed. Sweep rate is adjustable from 1 to 100 minutes through 10 to 2000 cps. Any portion of the 5 to 5000 cps freq band can be cycled continuously within ±10% of the center freq. Manual setting of correction rates is provided. Unit can also be used as a logarithmic wideband oscillator or as a vibration meter with an accuracy of ±3% of full scale.

For More Information Circle EQ RSC #1

* * *

AUTOMATIC TEST LOAD SPECTRUM PROGRAMMER

by Research, Inc., repeats material fatigue testing cycles through pencil-drawn charts mounted on rotating drums. Two function generators "read" the charts and guide the programmer through the entire test spectrum which can be repeated as many times as desired by setting a counter. The spectrum repetition rate is adjustable from 200 to 10,000 seconds.

For More Information Circle EQ RSC #2

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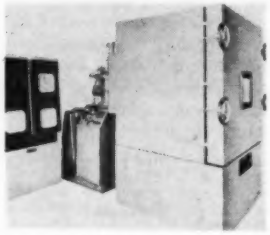
SPACE ENVIRONMENT SIMULATOR



Model WF-27-125+350, by Webber Manufacturing Co., Inc., is designed to simulate conditions at altitudes up to 500,000'. Pull-down to −125° F in 90 min, heat-up to +350° F, 60 min, cascade cooling system. Pressure of $4x10^{-6}$ mm Hg can be achieved in 45 minutes. Chamber interior is 3/8" stainless steel reinforced for $3.4x10^{-9}$ mm Hg without distortion at all temps. Internal dimensions: 36x36x 36".

For More Information Circle EQ RSC #3

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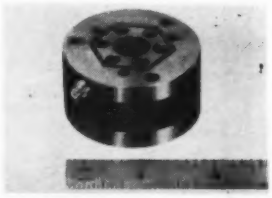
TRIPLE-TRANSDUCER FORCE GAGE



Model 2106 by Endevco Corporation for dynamic force measurement incorporates three Endevco force transducers in the same plane, providing high sensitivity of 7 pk-mv/pk-lb with the convenience of ½" center mounting hole. Flat configuration—1.935" diam x .973" high—permits stability with very little concern about shear loads. Both top and bottom surfaces are load-bearing members, resulting in stiffness of at least 2 x 10^{7} lb/in. Freq response, ±5%, 2 cps to 1/5 resonance freq with 1,000 megohm load and 5 cps to 1/5 resonance freq with 100 megohm load. Weight, .45 lb. Applications include measuring forces transmitted by liquid or solid fuel rocket engines or any rotating device to determine forces caused by unbalance, monitoring input force when electrodynamic shakers are used as drivers of complex structures and determination of dynamic loading characteristics of plastics and fibers. Price: $425.

For More Information Circle EQ RSC #4

* * *

OZONE COURSE TEACHING KIT

Kit O_3Q by Ozone Research & Equipment Corporation consists of an ozone generator and an 8-page booklet with instructions for demonstrations and experiments as well as important source references. While designed for visual demonstration of the production and effects of ozone in the classroom, the kit can also be used in research. Output of ozone is 0-20,000 pphm/volume.

For More Information Circle EQ RSC #5

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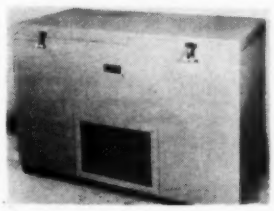
ALL-STEEL COOLING CHAMBER



Model PR110-N, by A. M. Harris Industries, Inc, has −60 to −110° F range and is designed for a wide variety of chilling services. Condenser is air cooled. Interior is 47x12x16" high. Exterior is 52x32x45" high. Designed for 230v, 60 cycle, 1 phase current.

For More Information Circle EQ RSC #6

AUTOMATIC CYCLING TEMPERATURE CHAMBER

by The Electric Hotpack Company, Inc., is equipped with dual timers and thermostats and an automatic overtemperature controller. Temperature range: −100° to +400° F, ±1° F. Coolant is liquid CO_2. Table-top model. Drawer has 10 openings for thermocouple leads. Cabinet exterior is gray enameled steel treated to resist rust; interior is 18-8 stainless steel. Chamber dimensions: 14 x 10 x 10" high.

For More Information Circle EQ RSC #7

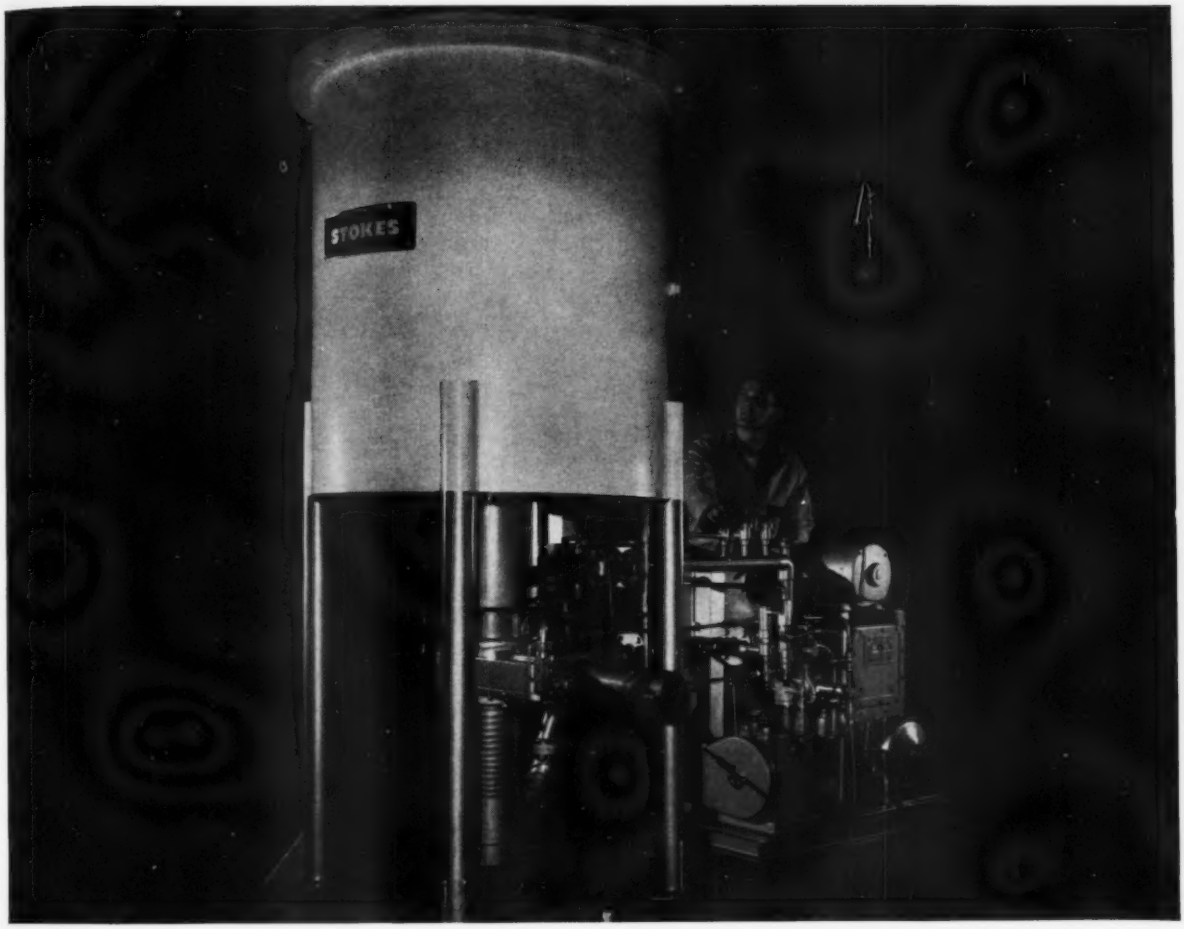
* * *

CLOUD AND POUR TEST CHAMBER

Model CAL-5-1-1 by Conrad, Inc., is equipped with five individually and thermostatically controlled temperature baths in the following ranges: −90° F, −60° F, −40° F, −20° F and +20° F. Each can be adjusted about 20° from nominal operating points. Unit, self-contained with F13 and F22 cascade refrigeration, is particularly designed for pour and point and viscosity testing of oil to ASTM requirements, but is suited to thermometer calibration and other temperature sensitive and electronics testing applications.

For More Information Circle EQ RSC #8

(For More New Products Turn to Page 32)



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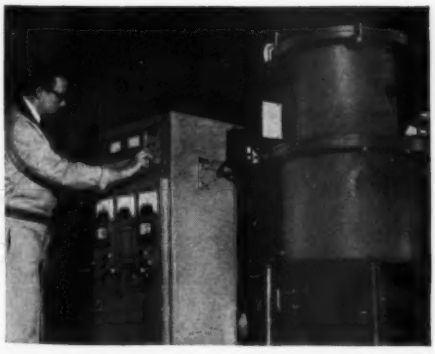

This new Stokes completely packaged Component Test Facility is currently being used to test components for space applications. The facility is designed to exceed the exacting test requirements of current government specifications.

This completely packaged Stokes environmental test facility greatly simplifies reliability testing of complete products destined for space environments. Products and subassemblies, such as cameras, transmitters, power supplies, can be evaluated under combined conditions of extreme low pressure and varying temperature. The facility is furnished complete with vacuum pumping system, test chamber, interconnecting piping, valving, and instrumentation. Performance capabilities range up to 10^{-8} Torr.

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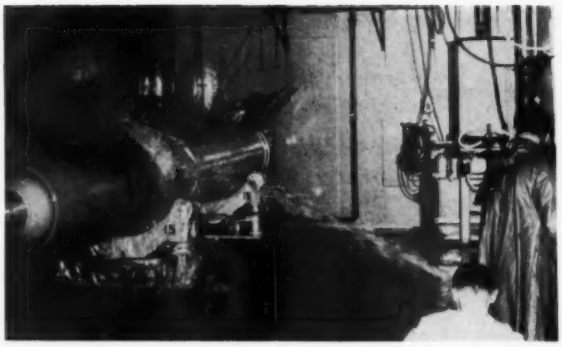


A TALOS MISSILE undergoes a salt water fogproof test at The Bendix Corporation's Mishawaka Division environmental lab.

COLD BARRIER CURTAIN minimizes heat gain while the missile is maneuvered into walk-in chamber for cold immersion and icing test.

Environmental Imagineering

by S. P. Sanders

Chief, Environmental Test Laboratory and Data Reduction Department, Bendix Mishawaka Division

TALOS ENVIKONMENTAL TESTING has featured a mixture of ingenuity, adaptability and improvisation.

Our laboratory for example, faced a requirement to test the missile under salt spray (fogproof) and salt water (splashproof) conditions. The fogproof test called for a low flow, moderate pressure (50 psig) salt water supply. The splashproof test, on the other hand, involved a high flow, low pressure (10 feet) supply. The problem was to provide controlled pressure and flow and a supply of salt water sufficient for a three-minute test.

To solve the problem, salt water in a 400-gallon, plastic-lined steel tank was pressurized with shop air through a pressure regulator. Under large flow, low pressure conditions, there was a considerable pressure drop in the hose. Therefore, the pressure was set with the nozzle pointing straight up, and air pressure in the tank was adjusted to give a 10-foot head of water, eliminating hose pressure drop completely.

Actually, the splashproof test required a higher air pressure than the fogproof test, even though the nozzle pressures were 10 feet of water and 50 psig, respectively. The 400-gallon tank was found adequate to meet both the flow rates and the test time called for by the specification. In connection with the requirement for sea water or its equivalent, a salinity study was made. It revealed that "sea water" varies from sea to sea. A 3 per cent by weight NaCl solution was chosen as a good "sea water equivalent."

Cold Water, Icing Tests

An allied problem was to develop techniques for cold weather and icing tests. The applicable mil spec required that the TALOS missile (all 3,000 pounds and 22 feet of length) be immersed suddenly in a sub-zero environment from a normal ambient temperature, and that a fresh water spray test follow the immersion. The spraying, of course, had to be done at the sub-zero temperature.

With an altitude-temperature-humidity chamber big enough and capable of −100° F, the basic equipment was available, but the test technique had to be developed. Initially, it was determined that there was a rapid heat gain, or cold loss, in the chamber when the 11 x 11-foot main door was opened.

Therefore, a cold-barrier curtain with a drop flap was installed, covering the entire door end of the chamber. The flap arrangement limited the cold loss to approximately 10° F per minute of open time, and it permitted a −20° F immersion test at a stabilized chamber temperature of −40° F. The differential was required because about two minutes were needed to move the missile into the chamber.

How To Remove the Water?

The scheme was very successful for the cold immersion test and for the first part of the icing test. A problem in the icing phase was how to remove water from the chamber. This was solved by spreading a heavy canvas, four feet longer and wider than the chamber floor, with the sides folded up, as a container. Then it was simply a matter of melting the ice and siphoning it down the drain after the test.

A question that then arose was: With piping and mist nozzles at a sub-zero temperature, would the water freeze

---

Sanders

S. P. Sanders has been in Mishawaka, Ind., and The Bendix Corporation's environmental test lab there since 1955. In those five-plus years he has been involved in all phases of environmental testing of the TALOS missile and its various systems, about which he writes. A 1949 mechanical engineering graduate of the University of Wisconsin, he joined Westinghouse in that year and worked in the East Pittsburgh plant on commutator design, balance and vibration problems and development of DC mechanical equipment until he left for Bendix. While in Pittsburgh he did graduate work at the University of Pittsburgh.

The constant effort to adapt available equipment and to develop new devices to satisfy mil specs and the demands of designers keeps environmental testing from becoming a humdrum operation. From a wealth of experience with the TALOS missile comes an account of environmental 'imagineering' that may help some, amuse others and perhaps induce all to share experiences.

and foul the nozzles? An experiment gave a surprising answer. The exit water temperature was found to be between 35° and 40°, or high enough to keep the piping from freezing, and heating cables were not required.

The spray system finally designed and installed in the chamber consisted of the 400-gallon supply tank, a main supply line, two parallel two-inch pipes approximately eight feet apart running parallel to the centerline of the missile and four feet above the centerline, and five rain nozzles in each pipe, spaced four feet apart. The supply tank was used instead of tap water for two reasons: The pressure would be controlled more easily, and the temperature of the water could be held constant during the test. The latter was important because icing at the nozzles is directly related to water-supply temperature, which was held to between 50° and 60° F.

Drawbacks of the Chamber

Whatever its advantages from an economic viewpoint, the combination temperature-altitude-humidity chamber had some technical drawbacks, minor, perhaps, but still of concern. The principal problem was getting rid of water vapor when an altitude test followed a humidity test. Altitude testing of the TALOS is not comparable to that of a space vehicle, because the TALOS has a ramjet engine, but a 10,000 to 20,000-foot difference in the capability of the chamber was important.

First the leakage rate was reduced to 7 cfm of ambient air at altitude conditions. With two full-size personnel doors, a large door exposing the whole end of the chamber, seven windows, numerous hydraulic and electrical feedthrough connections, and a two-section construction which permits partitioning to contend with, 7 cfm is an excellent accomplishment.

Then water was removed from the vacuum pump oil, using gravity separation and dry air stripping techniques. Literally quarts of water were removed after a prolonged humidity test and the ceiling was raised 10,000 feet, but the process was time consuming. It required several days of chamber conditioning. More recently, a commercial oil purifier has been obtained to do the job. It is quicker and more efficient.

Rapid Rate-of-Climb

Another problem faced by the lab involved a rapid rate-of-climb test. Using the big altitude-temperature-humidity chamber, with its 3,700-cubic-foot volume, as a vacuum reservoir, a climb rate of 80,000 feet in six seconds was achieved in a 28-cubic-foot bell jar. Considering that 13,000 feet per second is quite an achievement even in this space age, this was a rather remarkable feat. The problem now being studied in this connection is how to reduce and control the climb rate to the value required for a given missile system.

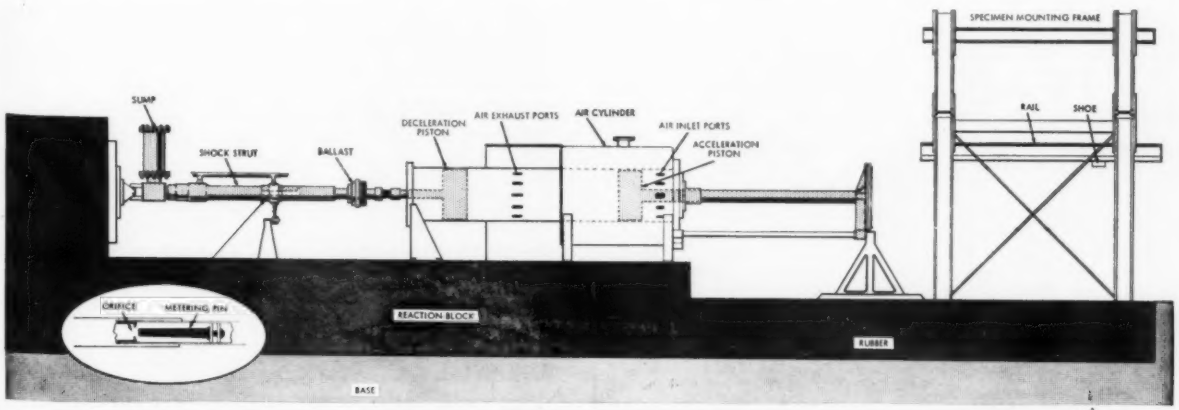
The versatility of the electric power supply in shaker systems is often very valuable. At Bendix it was demonstrated in a series of variation in-line voltage and variation in-line frequency tests on TALOS tactical test sets after an explanation by the lab's vibration expert as to how the rotary power supply of the 12,500-pound shaker system could be utilized. Since then the technique has been used in the lab many times. In some cases a transformer may be required to get the needed voltage. In addition to the voltage and frequency variation capability, rotary and electronic powered shaker systems are a satisfactory source of DC power at either 125 or 250 volts.

Shock Testing the TALOS

In 1952, early in the TALOS program, Bendix designed and built a pneumatic-hydraulic shock tester to simulate the start of the boost phase of the missile's flight.

Two shock testers were built, the first for specimens up to 250 pounds, the second to test the entire TALOS missile. With the missile shock tester, the impact is made in a horizontal plane with a total missile travel of seven feet.

The tester consists of a 30-inch diameter cylinder with two independently operating pistons. Air pressure at less than 100 psig is used behind one piston to accelerate the missile at approximately five gs for a distance of five feet. During this period the air in front of the piston is free



SHOCK TESTER DEVELOPED AT BENDIX MISHAWAKA for TALOS tests moves the entire missile seven feet horizontally.

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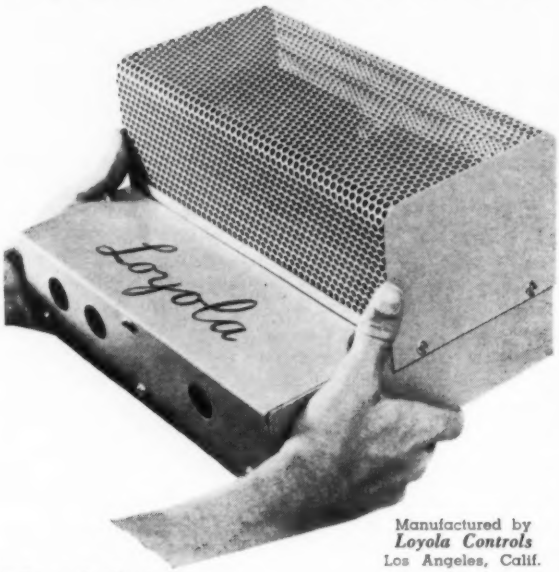

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to escape through exhaust ports in the cylinder wall. When the first piston covers these exhaust ports the air column trapped between the two pistons acts as an air spring to couple the moving missile to the energy-absorbing hydraulic shock strut. The hydraulic shock strut with its metering pin and orifice decelerate the missile smoothly with a rise time to peak g of about 20 milliseconds and a hold time over 90 percent of peak g of about 30 milliseconds. The missile is being decelerated backward, so the inertia forces which act on the missile are in the proper orientation to simulate the boost phase.

Several parameters can be changed to modify the response characteristics—air pressure, air column length, metering pin profile, metering pin-to-orifice distance and mass relationships. The response varies from a trapezoidal shape at 25 gs to almost a triangular pulse at 100 gs. This system has been shock testing the TALOS missiles for seven years.

A Switch on the G-Switch

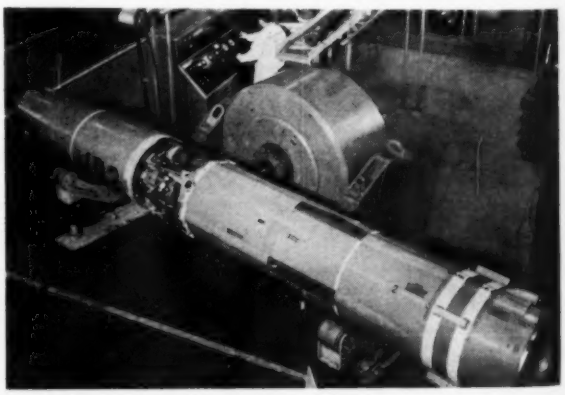
An interesting test resulted from a request by our engineering department to test a G switch. The switch was designed to be activated as it passed through a zero acceleration condition at a rate of 40 gs per second. Two methods were tried. The first utilized the component shock tester with exhaust ports closed. The system was essentially an air spring with a variable pneumatic source to give the switch an initial acceleration of about 5 g. The hydraulic shock strut helped to prolong the first cycle of the air spring's oscillation and a section of the first cycle's acceleration vs. time response approximated the test requirement.

The disadvantage of this method was that the vertical mounted component shock tester imparted a 1 g deceleration force to the switch prior to the start of the test cycle, and this force actuated the switch. Some device is required to hold the switch closed until the test cycle begins.

The second method used a compound pendulum mounted on the large centrifuge. When the pendulum was released it was free to swing through an arc of 180 degrees. At the end of the swing it was latched in its final position. With this system the G switch was mounted on the pendulum arm with its sensitive axis parallel to the centrifuge acceleration axis. The centrifuge speed was adjusted to give the 5 g acceleration required.

Advantages of the System

During the 180-degree swing the G switch experienced an acceleration reversal from 5 gs in one direction to 5 in the opposite. The acceleration vs. time characteristic was



Design margin evaluation tests are conducted at Mishawaka on this 12,500-pound force shaker.

elliptic (close to half a cosine wave), but during the important zero acceleration region the reversal rate was almost linear.

The system has many advantages. It performs the test as specified. It is easy to vary the parameters of the test. The starting G level is easily adjusted. The reversal rate is easily changed by adding weight to the pendulum to change its polar moment of inertia. (This adjustment is made by measuring the period of the pendulum swing. Naturally, the period is different in a one g gravitational field and an "X" g acceleration field on the centrifuge, but the difference effect is easily calculated.)

There are a few effects which should be considered. All the component axes are being subjected to the acceleration reversal. At the time the acceleration is zero in the sensitive axis of the G switch, the acceleration is maximum in a perpendicular axis. This wasn't important in our case because the moving element of the switch was constrained to move along a line, and the frictional effects were not considered to be harmful, but it may not be true in other applications.

The effect of the variation of the centrifuge radius arm was less than 5 per cent and was ignored. Coriolis acceleration was also neglected. During the tests the actual acceleration was recorded with Statham accelerometers, so these effects are included in the response curve. They did not contribute enough to be noticeable.

Shakers at Bendix

Bendix' environmental test lab has electrodynamic shakers of 12,500, 5,000 and 1,500-pound force systems. The electrodynamic shaker performance falls off in the low frequencies; below 20 cps it is quite poor. To overcome this deficiency in our shake equipment we did some experimenting with missile parts—servo amplifier, servo valve, wing actuator, and feedback potentiometer. The results of these experiments were so encouraging that we designed a 10,000-pound force system using missile parts with a commercial double-ended hydraulic cylinder. The system has dual shakers and worked well during a TALOS weapon container test series. Specimens up to 8,000 pounds total weight were tested between 2 and 300 cps. The output above 50 cps is always open to question, but we are satisfied with its performance below 50 cps.

A basic problem in a hydraulic shaker design is velocity-limiting in the system. Large force outputs with big displacements require high flow rates through the hydraulic supply, servo valve and cylinder. The missile servo valve was completely inadequate for a high force system, so two 45 gpm valves were obtained. This eliminated the velocity-limiting in the servo valve, but now there is a velocity limit in the hydraulic supply, the most expensive part of a hydraulic shaker system. A plan is now underway to utilize the 60 gpm, 5000 psi hydraulic power supply which drives the lab's large centrifuge to provide the large flow rates required for hydraulic shaker use.

The electronic portion of the system has also evolved. The new 45 gpm valve had different coil characteristics than the missile servo valve, so a new servo amplifier was designed. Piston centering and protective circuitry for the hydraulic shaker system are matters currently under study.

The hydraulic shaker system is excellent for combined vibration and sustained acceleration testing on a centrifuge if the vibration can be limited to the low frequencies. There is no critical problem with a hydraulic shaker in a high acceleration environment because the hydraulic cylinder is a rugged piece of equipment and will withstand large forces without extra support. •

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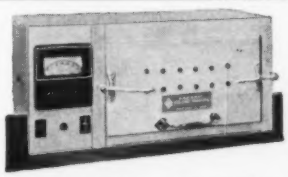

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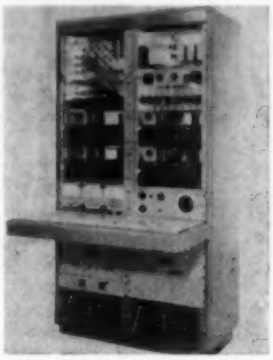

Model OF-3, by Ortholog Division of Gulton Industries, Inc., employs cross-spectral density computation technique to determine response characteristics of electrical networks and of control, structural and servo systems. Applications include vibration shake tables driven by a random signal, response of missile servo systems, and study of the human as a system element. Unit operates with random or complex periodic driving signals and provides output as Nyquist or Bode plots. Space occupied is equivalent to two 70" standard relay racks. Price, $25,000 to $30,000, depending on options.

For More Information Circle EQ RSC #9

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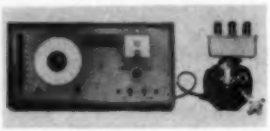
GAS ANALYZER FOR HIGH VACUUMS



by Consolidated Electrodynamics Corp. is designed for continuous and complete analysis of residual gases in systems at 10^{-4} to 10^{-9} mm Hg. Resolving power is said to be sufficient to separate adjacent peaks up to mass 20. Measurement of quantities of gas, gaseous mixtures and vapors over mass range of m/e 2 to 80 is indicated. Has self-adjusting central control function with manual feature. Power requirement is 3 amps, 105 to 125v, 60 cycles. Electronic module is 17½ x 11 x 8¾" high. Weighs about 50 lbs.

For More Information Circle EQ RSC #10

COMPACT, PORTABLE TEMPERATURE CHAMBER

Model 1060L, by Delta Design, Inc., is heated by electric elements and cooled by solid or automatic-flow liquid CO_2. Temp range is −100° to +500° F, with claimed control of ±.5° F. Test space, 10 x 7 x 7" high is accessible through drawer containing 10 sleeves for test leads. Operation is on 117v AC.

For More Information Circle EQ RSC #11

• • •

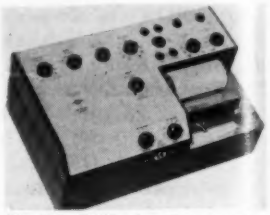
UNATTENDED OZONE RECORDER

Model L, by Ozone Research & Equipment Corporation, is advanced version of older models. It is designed for 10 days of unattended operation, while continuously recording, on a strip chart, ozone concentrations from 0 to 1,000 pphm/volume.

For More Information Circle EQ RSC #12

• • •

RECORDING VOLTMETER



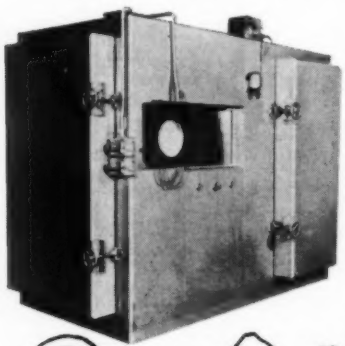
Model 2305 level recorder **by B & K Instruments, Inc,** measures true rms, average, or peak level of AC signals from 10 to 20,000 cps and DC signals to 10 cps through an internal chopper. Instrument operates as a null balancing, electro-mechanical servo with six linear or logarithmic recording ranges from 10 to 75 db. Indicated applications include noise and vibration testing and calibration of transducers and electronic devices. Dimensions: 19 x 12 x 9" high.

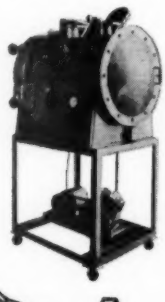
For More Information Circle EQ RSC #13

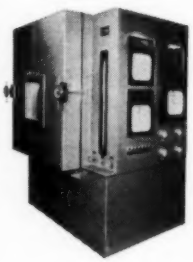
Environmental TEST CHAMBERS

Standard test chambers are expertly designed for accurate, reliable testing. Superior design and quality construction assure years of dependable service with a minimum of maintenance. Whatever the simulated condition desired, there is a Standard Cabinet designed specifically to do the job, guaranteed to give excellent performance.

Standard Cabinet Company, a recognized pioneer in the field, has an uninterrupted history of over 18 years under the same ownership and management. It has acquired a wealth of experience and skill in the design and construction of chambers of every description.







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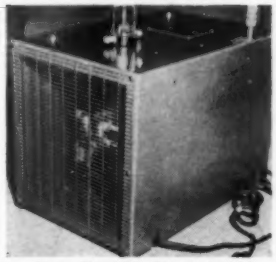
COMPACT CHAMBER FOR WIRE TESTING

Model WU-100-24, by Cincinnati Sub-Zero Products, provides temp range of +80° to −100° F, ±2° F, with pull-down from ambient in 1 hour. Contains self-supporting cone-step mandrell for testing on 2", 3", 4½" and 6" diam. Test load of ½-ton can be accommodated. Two multipane windows are 12x12x2" thick. Illuminated interior is 24x26x 72" high. Exterior is 34x36x 86" high. Power pack operates on 230v, 60 cycle, 1 phase current. Shipping weight is about 2000 lbs.

For More Information Circle EQ RSC #14

SELF-CONTAINED HEAT EXCHANGER



by **The Strong Electric Corporation** is rated at 12,000 BTU/hr in continuous use with 100° F ambient air and 180° F inlet water. Unit consists of gear-type pump, 1½-gal reservoir, cooling coil, fan, flow indicator, and associated fluid fittings. Pump and fan are mounted on the motor shaft. Pump can deliver 1¼ gpm with discharge pressure adjustable up to 100 psi. Permanent screen is installed in suction line. Pressure side has provisions for 5/8" OD copper or aluminum tubing. Wired for 115v, 60 cycle current, connections can be changed for 230v service. Current draw is 5.2 amps. Unit is 24x15½x20" high.

For More Information Circle EQ RSC #15

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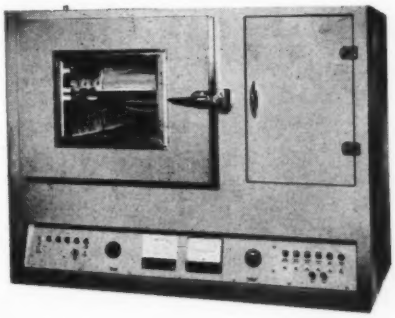
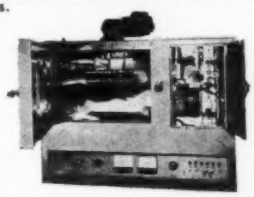
Shell Chemical Corporation



Orec 0300 Series employ an *electronic-chemical loop feed back servo system to achieve and precisely maintain chamber ozone concentrations.



Orec 0300 with Dynamic Stretching Apparatus.
* *patent pending*

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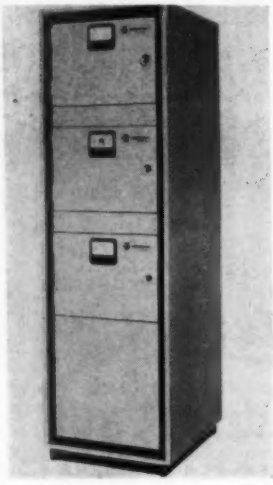

by **Research, Inc.**, for electric furnace control and other heavy power loads, has 630 KVA capacity and accepts either AC or DC control signals from an external controller or programmer. Advantages claimed are absence of power factor, instantaneous response, and smooth, proportional power, regulation from 5 to 95% of full power. Rated output is 450 amps in each phase at 230, 460 or 600 v. Overloads up to 100% can be tolerated for five minutes. Price, $3.450.

For More Information Circle EQ RSC #16

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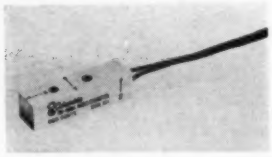
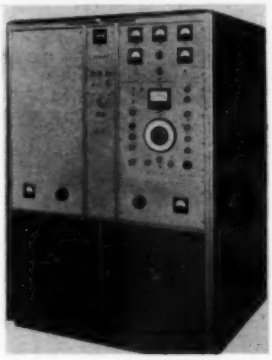
ULTRA-MINIATURE ACCELEROMETER



Model 606-TX, by Columbia Research Laboratories, for shock and vibration testing of printed circuit boards, electron tubes, sheet metal structures and other products. Device has sensitivity of 2 mv/g along X, Y and Z axes and flat freq response from .5 cps to 8 kc, ±5%. Resonant freq is 50 kc. Open circuit sensitivity is 5.5 mv/g, max acceleration is 1,000 g and amplitude linearity is ±2%. Temp range is —65° to +350° F for standard unit and —65° to +500° F for high temp unit. Stainless steel case is .4x.4x1.5" long. Weight: 8 gms. Price, $573.75 to $675, depending on quantity.

For More Information Circle EQ RSC #17

ELECTRONIC AMPLIFIER



Model T251, by MB Electronics, a division of Textron Electronics, Inc., has a 12 KW plate dissipation rating and is designed to power sinusoidal and random motion vibration test systems. Unit can produce 6000 volt-amps from 25 to 6000 cps into a resistive load with less than 3% distortion at full power. When used with MB C10 exciter, 1200-lb vector force is said to be available to 3000 cps in sinusoidal testing and 850-lb rms force over 20 to 2000 cps bandwidth in random motion testing. Vector force of 2200 lbs is available from MB C25H system with a 40 ips velocity limit and a 145-lb max specimen weight.

For More Information Circle EQ RSC #18

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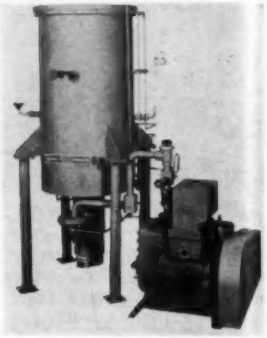
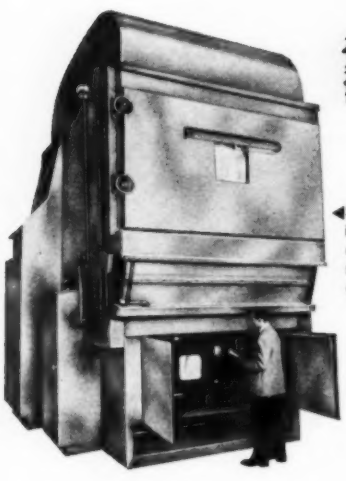
ULTRA-HIGH VACUUM PUMPING SYSTEM



Series 1450, by General Vacuum Corporation, is designed for extended testing in the 10^{-8} mm Hg range. System is valveless. Double-pumped O-rings and high-speed 6" diffusion pump are provided. Polished stainless steel liquid nitrogen baffle is integral with bottom chamber wall. Work space is 22x24." Options include baking equipment for 250° C.

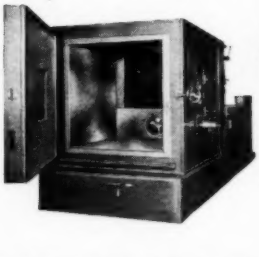
For More Information Circle EQ RSC #19

THE MOST ADVANCED TESTING TECHNIQUES ARE BEING BUILT INTO AMERICAN RESEARCH EQUIPMENT RIGHT NOW!

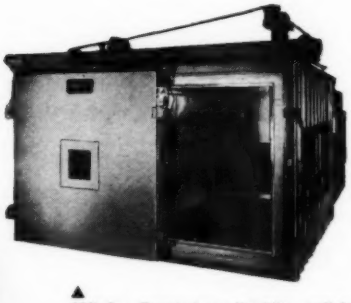


AR

Altitude chambers in any size —Altitude 200,000′ or higher; temperature +500°F and higher to —100°F and lower: Humidity 20% to 95%.



◀Sand and dust chamber includes automatic dust density control and streamlined air-flow design.



▲ Altitude, Temperature Humidity walk-in chamber 10′ high x 8′ wide x 12′ deep interior with push-button door controls inside and out.

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MEMBER OF THE ENVIRONMENTAL EQUIPMENT INSTITUTE

Tax-Exempt Research Expected in New Ruling

Scientific research carried on in the public interest will be exempt from taxation, according to a forthcoming regulation of the Internal Revenue Service. Research will be regarded as in the public interest if results are made available to the public on a nondiscriminatory basis, if it is performed for the United States, any of its agencies, or a state or a political subdivision, or if it is directed toward the public good.

Under the first requirement, all patents, copyrights, processes, or formulae resulting from the research would have to be made publicly available. An example of the third requirement would be research intended to aid in the education of college students.

At a second hearing on the new regulation, H. S. Beagle, president of Electrical Testing Laboratories, Inc., New York, offered a series of clarifying amendments. Mr. Beagle represented the American Council of Independent Laboratories, Inc.

North American Unveils Full-Scale B-70 Mockup

North American Aviation, Los Angeles, has unveiled a full-scale mockup of the B-70 jet bomber, which is expetced to be capable of carrying nuclear bombs at 2,000 mph over a 7,000-mile range. A flying version of the craft is slated for completion by Dec., 1962.

The B-70, more than 150 feet long, will be propelled by six J-93 turbojet engines and will cruise at 70,000 feet. Original plans called for construction of 162 planes at a cost of $10-billion. The program has since been reduced to two. Design expenditures already have reached almost $800 million.

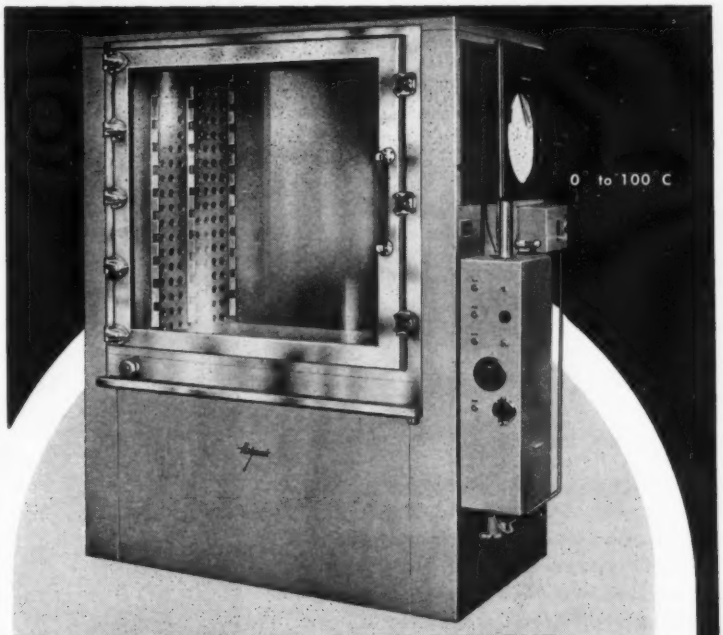
CEC Consolidates Divisions

Consolidated Electrodynamics Corp., Pasadena, a subsidiary of Bell & Howell Co., has combined its DataTape and Electro Mechanical Instrument divisions into a single unit, Data Recorders division. Henry S. Black, who headed DataTape, general manager of the new division, whose products include recording oscillographs portable test instruments and vibration meters.

Environmental Miscellany

New Business: A solar energy converter is being developed by *National Research Corporation*, Cambridge, Mass., under a $52,990 Air Force contract. A year's study and experimentation will be devoted to photoemissive devices which convert the sun's energy to electric power . . . *General Vacuum Corporation*, East Boston, Mass., has been awarded a GE contract for design and construction of one of the largest vacuum furnaces ever built. It will provide more than 4,500° F in a zone bigger than 1 x 2 feet in the area of 1 x 10.6 mm Hg.

LOOK FOR US AT THE IES SHOW BOOTH #61



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BEMCO, INC.'S, P-200W, one of series of small temperature test chambers. Channing Wallace Gilson, Los Angeles, was the industrial design consultant.

by Channing Gilson

Channing Wallace Gilson,
Industrial Design,
Los Angeles

Are engineers interested in appearances?

Emphatically yes, says an industrial designer, who notes that a poorly crafted enclosure may connote uninspired internal construction, while a well-executed housing bespeaks functional quality. Here's an example of environmental equipment that is . . .

Lovely to Look At

IF TEST EQUIPMENT IS AWKWARD in appearance, if craftmanship is poor and if repairs are difficult to make, the engineer using it is probably dissatisfied, no matter what its cost or how it performs. It is not consistent with the scientific approach to be precise in one area and crude in another—to fret over tolerances of internal parts while sloughing off a shoddy exterior finish.

Equipment eye appeal is far more than a matter of lines. At one end the concept embraces refinement of detail, simplicity of operation, economical production, safety, human factors, ease of maintenance and craftsmanship. At the other it embraces marketability. In execution it is a team effort, involving the industrial designer, design, development and production engineers, the sales department and management.

Other Features Emphasized

It brings other features to the fore, where they can be watched closely. As a result of an industrial design program for a new Ling Electronics shaker, Cameron Pierce, president, singled out manufacturing craftsmanship as an important control area, thereby making sure that every production unit came up to the high standards that had been set.

The manufacturer of a close-circuit television camera system often used to watch tests in progress in an environmental chamber, retained an industrial designer at the "breadboard" stage, to integrate form and function as the camera evolved. The designer contributed a new material, vinyl-clad access panels, and the use of extrusions in basic chassis design. Rather than specifying a superficial cover-up housing, the design approach led to an exposed chassis with satin anodized finish that did not need cover-up adornment. With the chassis also acting as a heat sink, conventional ventilation louvers were eliminated.

The trend toward eye appeal has caught on in other environmental test equipment areas. Here is the story of Bemco, Inc.'s P-200 series small temperature test chambers.

The chamber was developed to sell for around $440. Functional parts were to include normal controls, heating elements, cooling system, fan and motor, insulated chamber and six-port door with shelf for the part to be tested. The series eventually included a number of relatively inexpensive options, such as the P-200W with five-port door with a 4-inch window and a 4-foot flex line for liquid carbon dioxide supply, with drum adapter, at $14.50.

Bemco bought certain components of the chamber, fabricated others in its own shop and built a sheet metal shell prototype. Because the prototype model did well in tests, it was shown at a meeting of environmental engineers.

Prototype Revised

With the comments of potential customers in mind, Bemco undertook revisions of the prototype. At the same time, recognizing that its customers were used to precisely crafted electronic instruments, the manufacturer made plans to impress them with the operational sophistication of the product.

These chambers were to be sold primarily from catalog sheets, basically an illustration and statistical performance data. It was essential therefore, that the illustration convey a feeling of quality. For the photograph to catch this

feeling it was necessary that the product itself have it, in its basic design.

Designing the P-200 began at a conference attended by Warren Bruskrud, president of Bemco; Stuart Giles, chief engineer; Richard Schott, project engineer, and the industrial design consultant. For the consultant, orientation included a tour of the plant, to familiarize him with production capabilities, and a discussion of competitive products and of the market for the proposed chamber.

At a second meeting, the designers presented preliminary proposals on paper. One of the problems taken up was that of materials suitable for a chamber which would generate up to 600° F, and the not inconsequential hazards of, for example, improperly designed handles. Because of the heat, plastics were out of the question generally, ventilation had to be considered, and sheet steel on the outside and stainless steel interiors were mandatory.

A tilted panel had been built into the prototype, in line with the angle of the face of a temperature gauge whose probe enters the top wall of the chamber. This was kept in the final design because the gauge, control and switch settings are easily seen and operated from such an angle.

A number of perspective drawings were made. One of them incorporated the idea of isolating the chamber from its controlling elements. This was accepted because:

1. The same set of controls could be used on larger chambers, thereby producing a degree of standardization and lower manufacturing costs.
2. A separate enclosure for the controls made accessibility and maintenance easier.
3. Ventilation was improved by providing vent area to the front as well as the rear and around the instrument panel.

Hardware Problem Solved

Hardware presented a problem, but standard door locks giving a tight seal were finally located, and the industrial designer came up with a unique handle design. There were to be two handles, running horizontally at top and bottom across the full width of the door. This not only tied the handles in with other design elements, but allowed freedom of grip with or without gloves.

For the handles, the designers selected a functional, reasonably material, a dark phenolic impregnated wood laminate commonly used for kitchen knives. The material takes a high quality finish. Its strength, beauty, tactile warmth to the touch and insulating qualities have made the oft-used handles a high point of the design.

Cardboard Study Mockup

After the proposals on paper were accepted, a full-size cardboard study mockup was built. From this, color, size proportions and surface details were worked out, as well as such functional matters as how to locate and remove the top sheet metal housing, practical finger clearance distances and location of door handles.

Temperature gauge, temperature control, switches and indicator lights were placed on a horizontal center line on a matte white background, in logical sequence. The panel, mounted to the top surface of the chamber, is easily removed for maintenance.

The name BEMCO was prominently displayed in red on the panel, a signature to the manufacturer's achievement. Because the top housing is made separately, it can be enameled in another color. A medium gray blue, contrasting with the light blue of the chamber, was chosen.

The chamber is a simple, carefully proportioned rectangle. This shape was chosen as pleasing to the senses and one that adapts well to rack mounting, side-by-side arrangement, or even stacking, for which the fore and aft ventilation feature is ideal.

The P-200 is an example of industrial design that grew with and from the engineering. From such a combination come products that function better, have impressive, durable detail and are easier to manufacture and use.

(Details of Bemco's P-200: Temperature range: −100° to +600° F. Control tolerance: ±2° F. Pull down time: +70° to −100° F within 5 minutes. Pull up time: +70° to +600° F within 45 minutes. CO_2 consumption: 1 lb. per hour after pull down. Test space: 9 x 10 x 11". Exterior dimensions: 21½ x 14 x 18". Welded stainless steel liner, all steel case, drawer-type door, stabilized fiberglass insulation, two-tone blue baked enamel finish. Electronic resistance bulb temperature control. All controls in separate case.) #

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ENVIRONMENTAL BUSINESS...

Associated Testing Opening Third Lab, Located Near Boston

Its third test laboratory, located in the Northwest Industrial Park, Burlington, Mass., was opened in late March by Associated Testing Laboratories, Inc. The 13,500-square foot facility is on Route 128, known as the Electronics Highway, 17 miles from Boston.

William Tonkowich, president of the Wayne, N. J.-based company, placed Joseph F. Beattie in charge with the title of chief engineer. Until he joined ATL six months ago, Beattie was eastern division engineering sales manager for Ling Electronics.

Associated Testing reportedly is preparing to open its fourth test lab before the end of the year. It will be on the West coast.

At Wayne, the company has a 30,000-square foot operation in a recently constructed plant. It also manufactures environmental equipment there. The other ATL installation is a 10,000-foot lab in Winter Park, Fla.

Bernard Novack, vice president, said the Burlington lab would provide environmental test service for missile, rocket and aircraft components and systems to military specifications "for our growing roster of customers in the New England area." He said Burlington also will provide service and maintenance for users of Associated-manufactured environmental test equipment.

The new Associated Testing lab is ex-

(Continued on Page 40)

Gardner

Schletter

Dunn

Singer

Tenney Moves Into Acoustics Simulation, Organizes Four New Operating Divisions

Tenney Engineering, Inc., Union, N.J., which recently organized a Ground Support and Systems Engineering division, has entered the acoustics field and has divided its big environmental simulator business into two other functional divisions, Environmental and Aerospace.

Two veteran Tenney engineers, Frank Gardner and Martin Schletter, have been named managers of the Aerospace and Environmental divisions, respectively. William G. Dunn, formerly lead engineer of the acoustic test section of North American Aviation, Inc.'s, Dynamics Laboratory in Columbus, has joined Tenney to head the Acoustics division, and Edward J. Singer, formerly chief mechanical engineer of Flight Support, Inc., has been announced as manager of Ground Support.

The realignment gives Tenney five operating divisions. The fifth, headed by Sid Shapiro, a vice president of the company, is the Refrigeration, Heating and Air Conditioning Products division, whose plant is in Wilmington, N.C. Tenney also has two subsidiaries: Communication Measurements Laboratory, Plainfield, N. J., and Harvick Manufacturing Corp., Los Angeles.

Monroe Seligman, president, said the new assignments were "a natural development of our expansion program which has carried us from climatic to orbital simulation and into many areas of electronic and mechanical test equipment," and he added:

'New Concepts and Techniques'

"Simulators such as will be handled by the Environmental division were considered very advanced only a year ago, and are still very much in demand. But the race into space has created a parallel demand for orbital simulation, with new engineering techniques, multi-million-dollar contracts and different approaches."

Mr. Seligman said the Acoustics division's first assignment is "the development of sound source machines capable of intensities never before achieved." *(For a discussion of Tenney's current noise generators, see "New Product Spotlight" elsewhere in this issue.)*

Active in IES

Schletter, who joined Tenney nine years ago, is a national director of the Institute of Environmental Sciences and a past chairman of its Mid-Atlantic chapter. Gardner has been with Tenney for 10 years and is also a member of the IES. Dunn, who has taught acoustics and has published a number of papers on the subject, was with Convair-Fort Worth before he went with North American.

Ling Models Featured in New Vibration System

A new, advanced vibration system at Wyle Laboratories, El Segundo, Calif., shown testing a Titan II umbilical disconnect, includes: Ling Electronics' Model PP-40/60 40KW amplifier, Model A246 vibration exciter rated at 7,500 pounds force and Model ESD-20/ASD-20 spectral density equalizer/analyzer. The last permits continuous and parallel observation and control of spectrum in random vibration test programs. A tape recorder is used for a permanent record of applied vibration (power spectral density) for later analysis.

National Research Corp. Acquires Western Firm

National Research Corporation, Cambridge, Mass., has bought a controlling interest in Vacuum Apparatus Company, Palo Alto, Calif. Hugh S. Ferguson, president of NRC, said the move will help NRC "meet the expanding demand for high vacuum equipment" in the West.

Vacuum Apparatus, formed in 1958, designs high vacuum systems and provides leak testing and enigneering services. National Research, a major manufacturer in this field, develops high vacuum components, instruments and systems through its NRC Equipment Corporation subsidiary, located in Newton Highlands, Mass.

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EEI Annual Meeting Slated For April 5 in Washington

The annual meeting of the Environmental Equipment Institute, trade association of equipment manufacturers, will be held Wednesday afternoon, April 5, at the Sheraton Park Hotel, Washington, D. C., in conjunction with the IES meeting and show.

It has been customary for the institute to raise its executive vice president to the presidency. Currently holding the executive vice presidency is Warren R. Bruskrud, president of Bemco, Inc.

According to George R. Wilkinson, general manager of the EEI, the annual cost of doing business survey will be made available to members. As part of the institute's Seal of Approval program, plaques will be distributed for display in members' lobbies and waiting rooms.

Cryo-Therm, Inc. Enters Temperature Control Field

Cryo-Therm, Inc., has been organized in Fogelsville, Penna., as an affiliate of Standard Plastics, Inc., to handle research, development and sales in the areas of cryogenics and thermodynamics.

Charles Snelling, president of Standard Plastics, said recent developments include storage and controlled transfer of heat without use of electrical power. This, he said, points to "an entirely new approach to accurately controlled heat dissipation where fans and blowers cannot adequately control temperatures within required tolerances."

In the low temperature area, Mr. Snelling said, the company has developed a freezer providing programmed control from +20° to —200° C for environmental testing and freezing of biologicals.

Frozen Semen Products, Inc., manufacturer of low temperature freezing and shipping facilities, has become a division of Cryo-Therm. *(For more information Circle EQ RSC "C.")*

Harris Succeeds Shilstone As President of ACIL

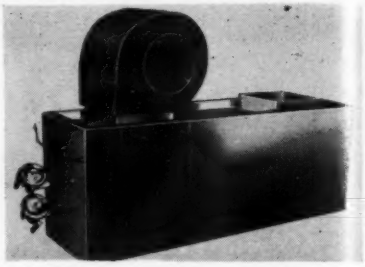
Lewis E. Harris, president of Harris Laboratories, Inc., Lincoln, Neb., has been elected president of the American Council of Independent Laboratories, Inc., succeeding Cecil Shilstone, of Shilstone Testing Laboratory, New Orleans.

J. Dickason, general manager of Metal Control Laboratories, Inc., Huntington, Park, Calif., is the Council's new president-elect. Other new officers are Fred Wright, vice president of Lucius-Pitkin, Inc., New York, treasurer, and Dr. Roger W. Truesdail, president of Truesdail Laboratories, Inc., Los Angeles, secretary.

Heads Electric Hotpack Sales

Electric Hotpack Company, Inc., Philadelphia manufacturer of controlled temperature equipment, has resignated Douglas M. Bergen as sales manager. He joined the company in 1956 as a sales representative.

Rempe Moisture Collector Used to Measure Radiation



A unique moisture accumulator has been designed by the Rempe Company, Chicago coil manufacturer, for a midwestern university to permit ambient radiation count.

The unit, described as an atmospheric radiation collector, is said to be capable of collecting a minimum of one quart of water a day from the air at temperatures ranging from —10° to +900° F. Application is indicated in a varity of laboratory and commercial processes requiring knwowledge of local radiation environments, and future models may find use in space environments, Arthur Vogel, general manager of Rempe. indicated.

The collector contains an internal fin coil and two independent circuits. Air makes four passes over the coil at a minimum velocity of 400 cfm. The upper circuit, designed for winter operation, can achieve a coil temperature of —35° F. A defroster consists of two 1,000-watt heaters. The lower circuit can maintain coil temepratures at +35° F in summer operation. Each section has an individual compressor.

The cabinet and all parts except the coil tubing are of aluminum. The blower exhausts against a static pressure of 1" water. *(For more information circle EQ RSC "B.")*

ATL Expansion

(Continued from Page 38)

pected to expand to a staff of more than 200. Don Jensen, a project engineer at the Wayne labs for 2½ years, has been promoted to assistant chief engineer at Burlington.

Before he went with Ling, Beattie was with Litton Industries and the Calidyne Corp.

Mr. Tonkowich, meanwhile, reported that Associated's sales hit an all-time high of $831,560 for the six-month period ended Nov. 30 last—almost double the $486,613 reported for the same period the year before. Net income for the six months rose to $88,048, more than double the $41,332 recorded the previous year. Per share earnings rose from 11.3 cents on 366,000 shares outstanding in 1959 to 19.7 cents on 446,000 shares outstanding this year.

The company expects sales in excess of $2 million for the fiscal year ending May 31 next and $4 million and possibly more, in 1962.

Howard

Hughes

Unholtz-Dickie, Strong Pick Hughes as Coast Rep

Don E. Hughes Co., 4459 Avocado St., Los Angeles, has been selected as a sales representative by Unholtz-Dickie Corporation, of Hamden, Conn., and by The Strong Electric Corporation, Toledo.

Hughes will represent Unholtz-Dickie's lines of electrodynamic vibration test equipment and Dial-A-Gain instruments for vibration measurement in Southern California.

In California and Arizona, he will represent the Strong blown type Jetarc solar radiation simulator.

Howard & Company, 938 N. Linden Ave., South San Francisco, headed by George Howard, is the new Northern California representative for Unholtz-Dickie.

CVC To Supply 50 Electronic Pumps

Consolidated Vacuum Corp., Rochester, N.Y., a Bell & Howell/CEC subsidiary, has received a $160,000 contract from the Cambridge Electron Accelerator Group, a joint undertaking of Massachusetts Institute of Technology and Harvard University, for 50 electronic vaccum pumps.

The pumps, known as DriVac ion pumps, will be used to evacuate an accelerator to further research in nuclear structure. Such research requires a continuous high vacuum free from contamination by pumping fluids.

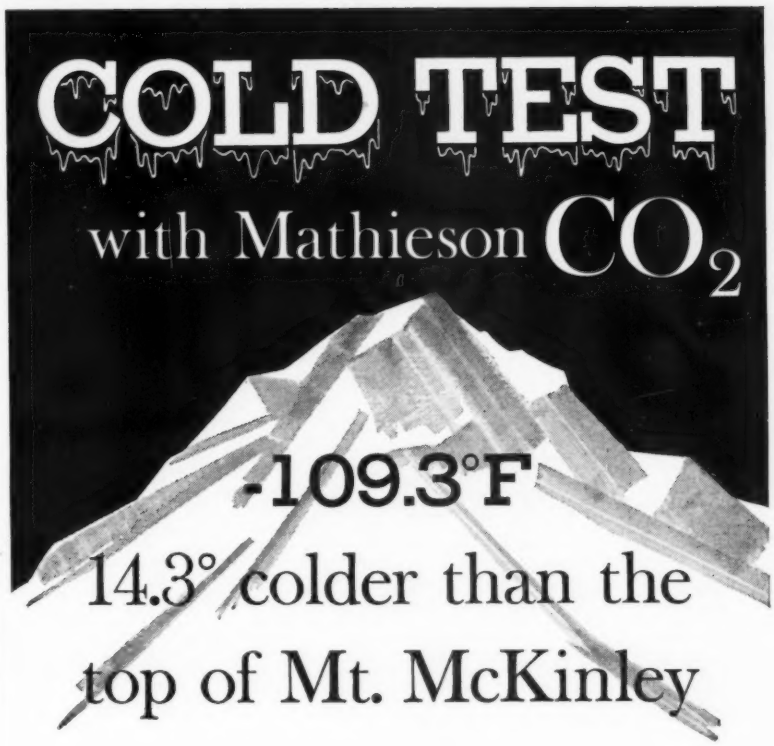
The DriVac pumps are capable of speeds of 300 liters per second. A triode design in the DriVac provides more than 10,000 hours life when operated at 1 x 10^{-6} mm Hg, and an increasingly longer life as the operating pressure nears the ultimate of 1 x 10^{-10} mm Hg. *(For additional information circle EQ RSC "G.")*

CompuDyne In Telemetering Field

CompuDyne Corporation, Hatboro, Pa., manufacturer of automatic controls and related instrumentation, has entered the telemetering field. Charles D. Close, president, said this will provide the company with "the final link to tie in its control systems to virtually all types of industrial processes."

Hancock Addresses New Yorkers

Warren D. Hancock, chief of technical services, Endevco Corporation, Pasadena, Calif., addressed the February meeting of the New York chapter of the IES. His subject: Impedance. The chapter has scheduled a tour of environmental facilities at the Brooklyn Navy Yard for May 18.



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*In 1932, the temperature at Mt. McKinley registered -95°F.

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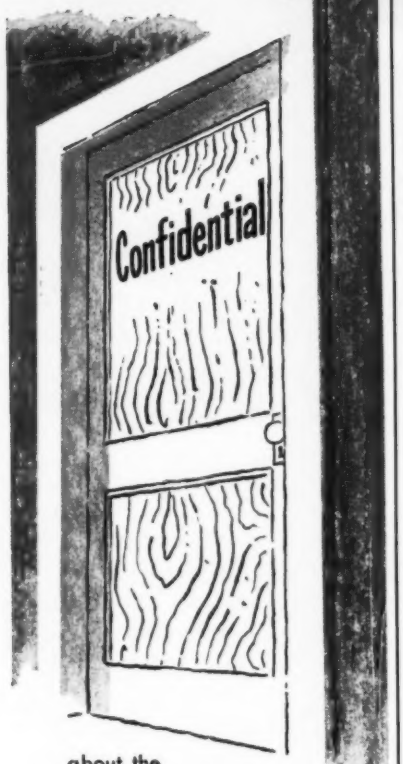

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Amorosi, IES Founder, Appointed to ETL Staff

Roger J. Amorosi, a founder and past president of the Institute of Environmental Sciences, has joined Electrical Testing Laboratories, Inc., New York, as assistant to the chief engineer. ETL is a 64-year-old independent laboratory organization specializing in electrical, electronic, environmental, chemical and photometric services.

Mr. Amorosi has been a project engineer at Sperry Gyroscope Company, and for eight years he was head of Parameters, Inc., now Wyle-Parameters, Inc., of Long Island, N. Y. He is a member of AIEE, Sigma Xi and other societies and is a registered professional engineer in New York state.

Norden Names Vavoudis Director of Reliability

Socrates Vavoudis, a national director of the I.E.S., has been appointed director of reliability by Norden Laboratories, Norwalk, Conn. Mr. Vavoudis has been associated with Itemco, Inc., and General Precision Laboratories. He is a past chairman of the New York chapter of I.E.S.

• • •

EDWARD L. BEAUDRY has been appointed eastern regional manager of field sales offices by TECHNOLOGY INSTRUMENT CORPORATION, Acton, Mass. His office will be in Rutherford, N. J. He was formerly sales manager of Mepco, Inc.

• • •

JAMES T. RUDIE, previously with Westinghouse Electric Corp., Baltimore, has joined LIBRASCOPE in Glendale, Calif. He is a member of the Institute of Environmental Sciences.

• • •

WILLARD F. BATES has been named director of manufacturing for the Data Recorders division of CONSOLIDATED ELECTRODYNAMICS CORP., a Bell & Howell subsidiary. He was formerly factory manager at Ryan Electronics division of Ryan Aeronautical Co. Also appointed in the Data Recorders division are **BURT W. COBB,** factory manager, **EDWARD P. FLEISCHER,** manager

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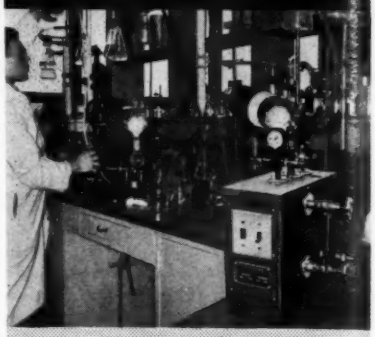

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of materiel, and **JOHN P. MITCHELL**, manager of manufacturing engineering.

* * *

GORDON THOMPSON has been named vice president and technical director of ELECTRICAL TESTING LABORATORIES, INC., New York. He had been chief engineer. **ERNEST H. SALTER**, former manager of the photometric laboratory, is now chief engineer.

* * *

LEWIS R. KOLLER has been appointed a research associate of NATIONAL RESEARCH CORPORATION, Cambridge, Mass., and **DILIP K. DAS** is a new project manager. Dr. Koller, a fellow of the American Physical Society, was formerly with GE Research Laboratories. Dr. Das was a section head at Raytheon.

* * *

ROBERT W. NOWACK has been appointed manager of engineering sales of MICRO GEE PRODUCTS, INC., Culver City, Calif. He was formerly sales manager of Metrolog Corporation, Pasadena, Calif.

Nowack

Sansone

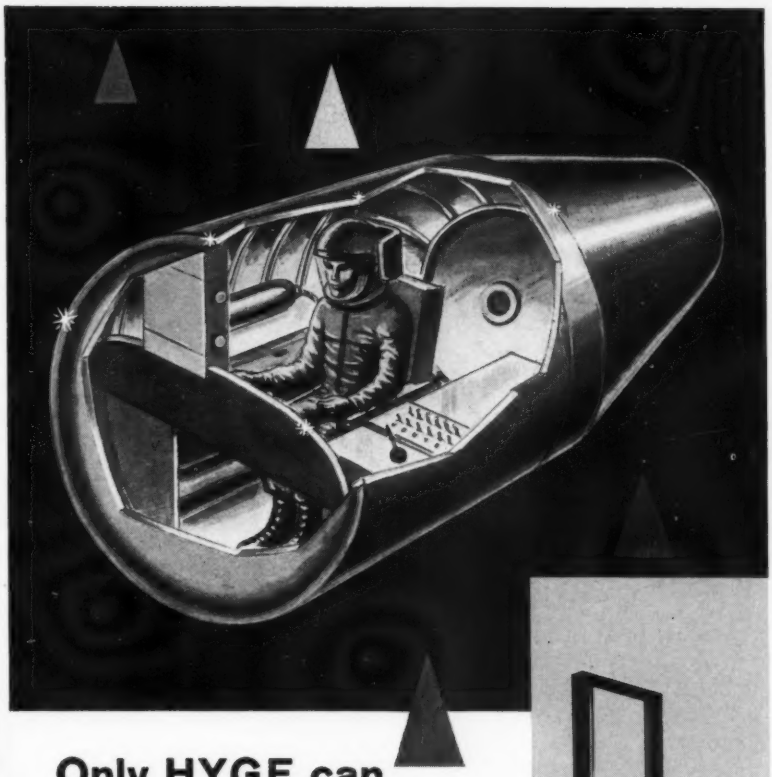
Rosen

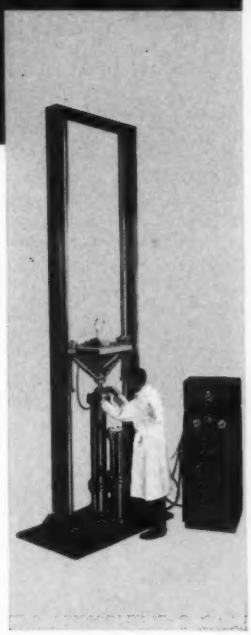
Posella

RALPH A. SANSONE, HYMAN ROSEN and **ANTHONY F. POSELLA** have joined the recently organized Ground Support and Systems Engineering division of TENNEY ENGINEERING, INC., Union, N. J. Their respective jobs are development engineer, chief electronic engineer and systems engineer. Sansone and Rosen are Newark College of Engineering alumni and both were formerly with Flight Support, Inc. Posella, a graduate of Stevens Institute of Technology, had been with GE.

* * *

ELWOOD C. WALKER, formerly chief vibration engineer with the Curtiss Propeller division, is now a consultant in the testing and test equipment field with offices in North Caldwell, N. J.





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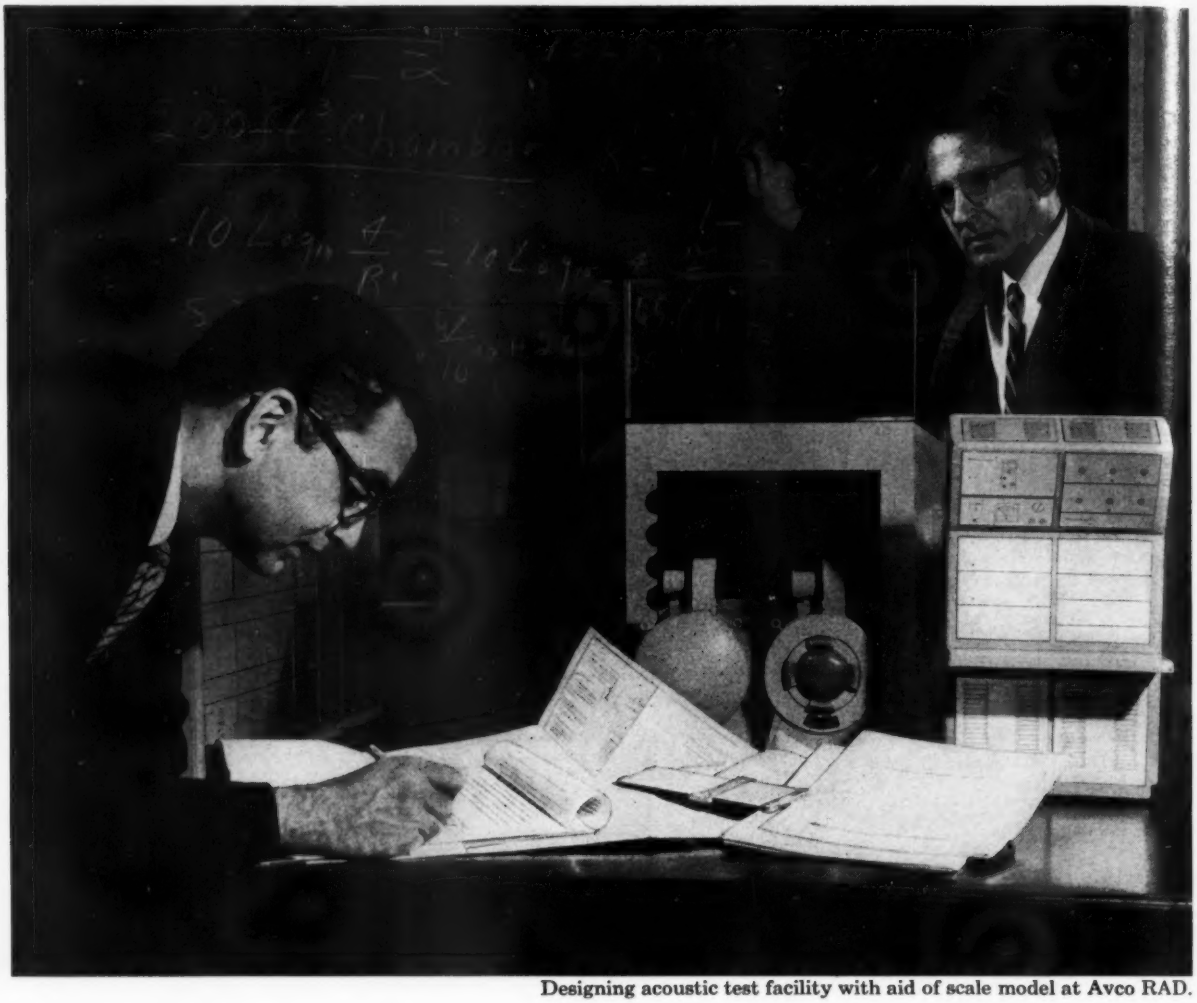

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For example, Avco recently developed an acoustic test facility for Sud Aviation to simulate rocket engine noise at its research center in Cannes, France. In this system, a single 3-KW Avco Noise Generator Type AG-012 replaces more than a score of conventional loudspeakers. Result: The Sud Aviation system produces up to 156 decibels in a 200-cubic-foot chamber, thereby permitting tests of specimens up to 20 cubic feet.

Advantages of Avco Systems:

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- **Produce true simulation of random acoustic noise environment—peaks over three times the rms level.**
- **Reduce cost by utilizing power amplifiers normally available in environmental labs.**

Heart of the Avco Systems is the AG-012 Acoustic Noise Generator. It will reduce system complexity and maintenance, provide more compact enclosure design, raise ratio of acoustic energy per square unit of chamber wall area, thereby producing higher sound pressure levels with less equipment.

Avco offers complete services in the design and construction of reverberation chambers and other components of noise testing systems.

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Your local Avco representative has a complete workbook describing Avco systems. Just tell him the sample size you want to test, the sound pressure levels you want to achieve, and he will outline the proper system for you. Offices throughout continental United States and the world. Or write: *Industrial Products Subdivision, Research and Advanced Development Division, Avco Corporation, Wilmington, Mass.*

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